

385.06

WR

v.11

Earning and Labor.

LIBRARY

OF THE

University of Illinois.

CLASS.

BOOK.

VOLUME.

385.06 WR

11

Books are not to be taken from the Library.

Accession No.

**This book has been DIGITIZED
and is available ONLINE.**

Official Proceedings

OF THE

Western Railway Club

FOR THE

Club Year of 1898-9

The Club meets the third Tuesday of each month, except June, July and August.

The Club Year ends with the meeting in May.

PUBLISHED BY THE

WESTERN RAILWAY CLUB

Chicago, Ill.

Printed by the W. F. Hall Printing Company
21-23-25 Plymouth Place

1899

LIBRARY
UNIVERSITY OF CHICAGO
OCT 1 1898

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

(INCORPORATED.)

SEPTEMBER 25, 1898.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 1.

CHICAGO, ILL.

{ \$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Roadmaster, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER.	JOHN W. CLOUD.
F. W. BRAZIER.	H. G. HETZLER.
PETER H. PECK.	F. W. SARGENT.
PROF. WM. F. M. GOSS.	

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio.

A regular meeting of the Western Railway Club was called to order at 2 p. m., Tuesday, September 20, 1898, in the Auditorium Hotel, Chicago. President C. A. Schroyer in the Chair.

Following are the names of those who registered:

Akerlind, G. A.	Fildes, Thos.	Morris, A. D.
Anderson, Thos.	Giroux, Gustave.	Morris, T. R.
Anderson, Geo. T.	Goehrs, Wm. H.	Noble, L. C.
Ball, H. F.	Gordon, Frank L.	Parisoe, Louis.
Barber, J. C.	Gowing, J. P.	Pickels, Wm. D.
Billingham, Jos.	Groobey, Geo.	Royal, Geo., Jr.
Bischoff, G. A.	Haskell, B.	Sawyer, Ed. C.
Brazier, F. W.	Hawkesworth, D.	Scales, R. P.
Brown, Benson E.	Horrigan, J.	Schroyer, C. A.
Buker, J.	Hubbell, Harry M.	Scott, G. W.
Carse, David B.	Hyndman, F. T.	Sharp, W. E.
Chambers, J. S.	Johann, Jacob.	Shea, R. T.
Church, Townsend V.	Keegan, J. E.	Slater, F.
Clifford, C. J.	Keeler, Sanford.	Smith, R. D.
Coleman, J.	Kershaw, J. A.	Smith, J. E.
Condron, T. L.	Kirby, T. B.	Stafford, B. E. D.
Cooke, Allen.	Kuhlman, H. V.	Street, C. F.
Crawford, H.	Luttrell, J. W.	Thurtell, B. W.
Crosman, Walter D.	Mabbs, J. W.	Vissering, Harry.
Cushing, Geo. W.	Mackenzie, John.	Waitt, A. M.
Deems, J. F.	Marshall, W. H.	Wakeman, C. J.
Delano, F. A.	Marshall, William.	Whitridge, J. C.
Doebler, C. H.	Mason, Geo. G.	Whyte, F. M.
Eames, Ed. J.	McMaster, T. J.	Woods, J. L.
Elliott, W. H.	Mileham, C. M.	Woods, E. S.
Forsyth, A.		

PRESIDENT SCHROYER: Gentlemen, the meeting will please come to order. The first order of business is the reading of the minutes of the last meeting; but, inasmuch as all the members are in possession of the printed minutes, it is not necessary to read them, and unless there is some objection to them they will stand approved as printed in the Proceedings. Hearing no objection, the minutes are so approved.

The next order of business will be the announcement of new members; there are thirty-eight of these. Before the Secretary reads the list I wish to make a few remarks about the present membership and of some actions which have been taken by the Directors in relation to those members who are delinquent for dues. Sixty-seven names have been dropped from the roll of membership on ac-

count of the non-payment of dues, the dues in each case extending back over a period of three years. There are ninety-eight names now on the rolls, of members who are in arrears two years for dues, or \$4.00 each. These members have not been suspended, but their names have been taken from the mailing list of this Club, and neither the Proceedings nor notices of meetings will be sent them. If you come in contact with any of the members in this class, please urge them to meet the requirements and become members in good standing. There are 335 names on the rolls today of members who are in debt to the Club to the extent of \$2.00. The Directors have decided that the Club can not purchase Proceedings of other clubs for members of this Club who do not pay their dues as the rules require, and have ruled that unless members are in good standing the Proceedings of other clubs cannot be sent to them on the exchange list. Those whose dues are not paid to May, 1899, are not in good standing.

The Secretary then read the following list of applications for membership which had been acted upon favorably by the Directors:

E. P. Amory, Sec'y Western Railroad Association 1330 Marquette Bldg., Chicago, Ill.

A. W. Barr, Round House Foreman, C., M. & St. P. Ry., Green Bay, Wis.

Edw. C. Bates, Crosby Steam Gage Co., 97 Oliver St., Boston, Mass.

Percy H. Batten, Special Apprentice, C. & N.-W. Ry., Chicago,

Angus Brown, S. M. P. & C., Wisconsin Central Ry., Waukesha, Wis.

Benson E. Brown, Sales Mgr., Acme White Lead & Color Works, Detroit, Michigan.

Oliver C. Cromwell, Chief Draftsman B. & O. Ry., Mt. Clare, Baltimore, Md.

Wm. R. Ellis, Supt. Car Building, Ill. Car & Equip. Co., Hegewisch, Ill.

Chas. L. Gately, Mgr. Ry. Dept. N. Y. Belting & Packing Co., 25 Park Place, N. Y.

F. Hildebrandt, Car Foreman, C. R. I. & P. Ry., Rock Island, Ill.

Willis Hall, Foreman, L. S. & M. S. Ry., Chicago.

R. E. Jacobs, Representative Keasbey & Mattison, Utica, N. Y.

Willard Kells, M. M., C. & E. R. R., Huntington, Ind.

Jacob Kastlin, General Foreman, C., B. & Q. R. R., West Burlington, Iowa.

Maxwell A. Kilvert, Genl. Agent, Washburne Coupler Co., Chicago, Ill.

J. W. Leonard, Genl. Supt., Canadian Pacific Ry., Toronto, Ont.

W. W. Lowell, M. M., H. & St. J. R. R., Brookfield, Mo.

Wm. Marshall, Sec'y and Genl. Manager, Anglo-American Varnish Co., Newark, N. J.

Thomas Mason, Chief Clerk M. P. Dept., B. & O. Ry., Mt. Clare, Baltimore, Md.

M. McCarthy, Machinist, C., B. & Q. R. R., West Burlington, Iowa.

J. A. McRae, Draftsman, C. & N.-W. Ry., Chicago, Ill.

A. C. Miller, Chief Train Dispatcher, C., B. & Q. R. R., Aurora, Ill.

John P. Murphy, Storekeeper, C. & N.-W. Ry., Clinton, Iowa.

John P. Neff, Draftsman, C. & N.-W. Ry., Escanaba, Mich.

G. B. Nicholson, Chief Engr. and Purchasing Agent, C., N. O. & T. P. Ry., Cincinnati, Ohio.

Chas. H. Osborn, Apprentice, C. & N.-W. Ry., Chicago, Ill.

Geo. C. Purdy, Genl. Mgr., Greenlee Bros. & Co., Chicago, Ill.

E. A. Sherlock, Park Bros. & Co., Ltd., Chicago, Ill.

F. H. Smith, Supt., Hewitt Mfg. Co., Chicago, Ill.

R. H. Soule, Baldwin Loco. Works, Chicago, Ill.

C. W. Spencer, Genl. Supt., Can. Pacific Ry., Montreal, P. Q.

Thos. Tait, Manager, Can. Pacific Ry., Montreal, P. Q.

H. P. Timmerman, Genl. Supt., Can. Pacific Ry., St. Johns, N. B.

A. H. Thomas, M. P. Dept., P. C., C. & St. L. Ry., Columbus, Ohio.

George F. Wall, Motive Power Insp., Pa. Lines, Fort Wayne, Ind.

E. T. White, M. M., B. & O. Ry., Riverside, Baltimore, Md.

J. C. Williams, Phenix Metallic Pkg. Co., Chicago, Ill.

G. A. Woodman, Asst. to M. M. Swift & Co., Chicago, Ill.

PRESIDENT SCHROYER: The next order of business is new business, and under this head the Secretary will read a communication from the Western Society of Engineers, and one from President J. H. Smart, of Purdue University.

CHICAGO, ILL., September 19, 1898.

Mr. F. M. Whyte, Sec'y Western Railway Club.

DEAR SIR:—This Society desires to extend a cordial invitation to the members of the Western Railway Club and their friends to attend a lecture to be delivered on Wednesday evening, September 21, 1898, in Steinway Hall, by Col. H. G. Prout. The subject of Col. Prout's lecture is "Soudan and the recent British campaign there."

Yours truly,

T. L. CONDRON,

Chairman Publication Committee.

Mr. F. M. Whyte, Sec'y Western Railway Club, Chicago, Ill.

DEAR SIR:—I beg to acknowledge your letter of the 7th, with regard to the resolutions of the Western Railway Club. The framed copy of these resolutions was received yesterday. Permit me to say that I am very much gratified, not only by the honor bestowed on Purdue by the visit itself, but especially by the expressions of confidence and good will contained in the resolutions. They will stimulate all of us, both faculty and students, to greater efforts to deserve the esteem of our friends.

Very truly yours,

July 13, 1898.

J. H. SMART.

It was moved by Mr. Rhodes that the Secretary be instructed to acknowledge the receipt of the invitation of the Western Society of

Engineers with the thanks of the Club; the motion was seconded and carried.

PRESIDENT SCHROYER: The officers of the Club desire it to be understood that they are not wholly responsible for the success with which the Club may meet; most of the responsibility is with the members and the members should not hesitate to do their full duty. The Club desires to receive papers on all subjects relating to railroads, and the officers trust that the members will feel more at liberty to submit papers and to take part in the discussions before the Club. The stenographer's notes of the remarks made are submitted to each speaker before the remarks are printed in the Proceedings, so that each speaker has an opportunity to revise what he says at the meetings; with such arrangements the members should not be timid about expressing their ideas.

The President then introduced Mr. G. W. Scott, who read the following paper on: "Heating large railroad stations, shops and buildings."

HEATING LARGE RAILROAD STATIONS, SHOPS AND BUILDINGS.

BY MR. G. W. SCOTT.

In many instances railroad superintendents of machinery, master mechanics, or other persons in charge of power stations, shops, and plant equipment generally, are so engrossed with the exacting cares of their onerous duties, that but little time is at their disposal for any attempt at investigation concerning matters not directly in the line of their immediate pursuit. It thus frequently happens that while the highest intelligence may be directed in the line of securing close economy in matters of locomotive and car construction, and the maintenance of the mechanical features of a railroad in general, in other, and, perhaps, seemingly only associated matters, there is oftentimes an entire lack in realizing results frequently less difficult of attainment than many of the more diligently pursued problems.

As an instance in point, reference may be made to the methods of heating large railroad stations, work shops, office, and other buildings. How frequently may one find such buildings heated by live steam, the while large quantities of exhaust steam from stationary engines, pumps and other steam actuated mechanism, may be seen discharging into the atmosphere. If this condition was an unavoidable one, there would be no need to call attention to so common a fact; but inasmuch as it is not a necessary condition, but altogether an unnecessary and wasteful one, it becomes a matter of duty for those in charge of such institutions to consider ways and means by which to obviate the

burden and cost of the coal involved in the generation of live steam for heating purposes.

True economy in mechanical and engineering matters is never so sure and easy of attainment as when the object to be gained is made the purpose of intelligent study rather than the result of a speculative or haphazard finding. And in the subject before us, there is positively no room for doubts, no room for vague misgivings but altogether a decided reliance upon the fundamental teachings of the science of thermodynamics.

Admitting that the heating of such buildings is an imperative matter, the question arises: What is the best agency to employ in order that the highest results may be attained? And if we grant that, for many reasons, steam is the most advantageous heating agent known to us at this time, the next question is: How to secure the necessary heating effect with the least possible expenditure of money for the steam employed? In the large majority of instances this question, if asked at all, is answered by a reference to what other people have done or are now doing; and seeing that very many otherwise well-directed mechanical institutions use live steam for steam-heating purposes, it is not altogether surprising that such practice has come to be regarded as one eminently proper, if, indeed, there is any other choice.

Now, all this is nothing more or less than a blind acceptance of traditions and ill-advised customs, and all seemingly without a thought concerning the fundamental principles involved. It would appear as if the simple truth was lost sight of that steam, like any other energized agent, will move in the line of least resistance, and that if the resistance increases, more steam—that is, more energy—is necessary. Correspondingly, if the resistance be lessened, then the amount of energy required may be reduced. And when we speak glibly of so many “pounds pressure” being absolutely required, we are apt to lose sight of the fact that, in this instance, the main point in view is to convey heat, and this with the least expenditure of energy, and with a minimum cost of fuel.

Recalling the passing reference to a force moving in the line of least resistance, it will be readily accepted that if in a steam heating circuit we can reduce the resistance—whether that resistance be set up by the presence of condensed water or of air—steam of less energy than otherwise will be capable of flowing through the heating system. Now, such reduction of resistance is clearly possible by the attachment of a pump in connection with the so-called returns from the various heating centers; the office of the pump being, first, to withdraw air and condensed water from the returns at the base of the heating centers; and, secondly, to effect a partial vacuum on the return side of the various radiators, coils and what not. In fact, merely do in the case of the heating system what is done in the condensing engine; that is, the obtaining of a partial vacuum in the path of the advancing force.

Admitting, then, that by reducing the internal resistance within the heating system, it is possible to employ steam of a lower pressure than commonly used, and that even steam at atmospheric pressure may be employed under such conditions, it need only be shown how in practice this result is brought

about. And here the writer has in mind plants involving numerous office buildings, shops, lumber and other kilns, all heated by exhaust steam from engines, pumps, steam hammers, etc. He is also cognizant of such large railroad buildings as that of the Chicago & Northwestern and the Pennsylvania stations in Chicago. These latter, indeed, are exceedingly interesting cases; and while many are familiar with the long line of offices, baggage, immigrant, mail and other rooms, few people may know that the buildings in question, measuring, in the case of the Pennsylvania station, some 1,800 feet in length, are heated by the exhaust steam from the power station situated at one end of the line of buildings; and that from this steam plant the exhaust steam passes through numerous lengths and turns of heating pipes, now up, now down, and finally, through the agency of the pump (usually termed a vacuum pump), the condensed steam is drawn back to the power station and to the feed water heater, thence to the boilers, to be again converted into steam; and after performing its function in the steam cylinders of the engine or pumps, again goes on its mission of affording genial warmth to the mass of people whose varied businesses brings them within the buildings in question.

The following general considerations may serve to facilitate a clearer comprehension of the subject in question, as well as to show the economical advantages attending the use, under proper conditions, of exhaust steam for heating purposes.

If steam is to be used for motive purposes, then the matter of pounds pressure per square inch is all important; but if the steam is to be applied solely as a heating agent, then the question of pressure per square inch is not so material, seeing that within ordinary limits the heating value of steam is almost constant. By the expression, "heating value of steam," reference, of course, is made to the total number of heat units contained per pound weight of steam. For example, while steam at atmospheric pressure, or 14.7 pounds absolute pressure per square inch, has a sensible temperature of only 212 degrees F., it contains 1,146.6 total heat units above 32 degrees F. And while steam at 5.3 pounds gauge pressure, or 20 pounds absolute pressure per square inch, has a higher sensible temperature, namely, 227.9 degrees F., yet the total quantity of heat units above 32 degrees F. is only 1,151.5, or but 4.9 heat units more per pound of steam than the steam at 212 degrees F. In other words, steam at a gauge pressure of 5.3 pounds per square inch has a value for heating purposes of something less than one-half of 1 per cent. over steam at atmospheric pressure.

We are all familiar with the fact that a heat unit is the measure of the quantity of heat required to raise the temperature of a pound of water one degree Fahrenheit; and we may, therefore, appreciate the value of one pound of so-called exhaust steam, even at atmospheric pressure, when we realize that it contains 1,146.6 of such units.

Few workshops, or even railroad stations, are required to be heated above 70 degrees F. And when it is further recognized that only about one-fourth the quantity of heat is required to heat air compared with water (the base of all specific heats), it may be seen what an exceedingly large storage of heat supply is contained in the ordinary cast off exhaust steam.

Now, whatever may be the ultimate nature of heat, everyone is cognizant of the fact, that it may be transferred from one body to another, and that the direction of motion is from the higher temperature to the lower. In the case before us, the motion is from the steam to the heating pipes, and from the pipes to the atmosphere within the room; and knowing the specific heat of air to be about 0.2375, and also knowing the conductivity of the metal composing the pipe, it becomes a matter of only a few figures to determine just how much steam is required, and just how many superficial feet of piping are necessary to raise the temperature of the air within a room to any ordinarily desired degree of heat. However, there is no need to call in the services of an expert mathematician, for, based on the results of general practice, it is found that workshops and other buildings may be maintained at a temperature of about 70 degrees F. in zero weather, when the steam supply is equal to one boiler horse power, or $34\frac{1}{2}$ pounds of steam per hour for each 100 superficial feet of piping or radiation; and that this amount of radiation is ordinarily abundant for each 10,000 cubic feet of air within the room.

Suppose, for example, the exhaust steam available is that from engines and pumps using 200 boiler horse power. Then, according to the above, this would be sufficient to heat 2,000,000 cubic feet of shop space; and all this, so far as fuel is concerned, practically without charge. To compare this freedom of charge with the cost of heating with live steam, is to simply find the value of 200 times, say, 5 pounds of coal per horse power, or, say, 1,000 pounds of coal per hour. And taking the cost of coal and labor at only \$2.00 per ton, the saving on this account would be no less than \$1.00 per hour.

Having thus touched upon what may be obtained, it may be in order to describe the method of application. Instead, then, of allowing the exhaust steam to escape into the atmosphere, connect the exhaust pipe to the main pipe of the heating system; but, for obvious reasons, retain an exhaust outlet to the atmosphere, inserting in the same a back pressure valve which, under ordinary circumstances, may be loaded to about one-half pound per square inch. The exhaust steam will then flow through the mains and into the desired units of radiation, there to transfer its heat through the pipes to the air beyond. Quite naturally, as a result of the process of heat transference, condensation will take place, and, with the entrained air, tend to accumulate in the pipes and coils, but only momentarily; for in such a system as the one referred to, the air and water, by their thermic influence on certain thermostatic valves, effect their own admission into the return pipe, from which they are discharged by the action of the associated vacuum pump—the air escaping into the atmosphere, and the water, still hot, passing into the feed water heater, thence to the boilers.

The underlying philosophy in all this is the creation, by the pump, of a partial vacuum in the return pipes; and, in addition, the automatic action of the thermostatic valves; the latter readily opening under the cooling influence of the presence of air and water, and just as readily closing when surrounded by the incoming steam. And thus it is that the radiators or coils may be automatically held full of steam, entirely free from pounding noises, lowering temperature and other annoyances incidental to systems less scientifically designed and installed.

But the highly appreciable reduction in cost of labor, fuel and maintenance, by the employment of such a system of heating, is not the only desirable feature obtainable, there being another and no less worthy result—that of the ability to return to the boilers practically pure water, or at least water from which the previous steaming has freed from it an appreciable quantity of lime, magnesia and other incrustating associates. At the works with which the writer is connected, many tons of condensed steam are hourly returned to the boilers; and all this after the exhaust steam has performed its service of heating in connection with numerous office and shop buildings, dry rooms, lumber kilns, etc.

To the mind of the writer this last result is an exceedingly valuable one; for all who have been, or who are, concerned with boiler management, know only too well the uneconomical results—not to speak of the possible ill effects—arising from incrustated boiler tubes and sheets. True, the condensed steam returned to the boilers by the use of the exhaust steam will not, in ordinary practice, approximate the amount of water required for steam purposes; still, the relative volume may be of such moment as to materially dilute the deleterious elements in the added water; and in this manner the returned water becomes an active agent in the reduction of scale-forming material within the boilers.

But even this is not the end of the many striking advantages of this system of heating; for, and beyond all question, the cost of installation is appreciably less than in the case of the high pressure system. And equally in favor of the "vacuum" system is the low cost of maintenance and renewal of piping. The reason for this is attributable to the fact that in the "vacuum" system the steam is at a lower sensible temperature than in the other case; and, also, there is less water of condensation in the returns of the "vacuum" system compared with the more congested condition of the returns in the "high pressure" system. This, indeed, is a natural result, seeing that the corrosion of iron by the action of water is somewhat dependent on the degree of temperature, as well as the volume of water coming in contact with the surface of the metal.

As a closing remark, it may not be altogether out of place to briefly refer to the subject of heating passenger, sleeping, mail and express cars. The prevailing method of applying steam to cars for heating purposes, is essentially a "high pressure" one, involving the use of steam at anywhere from 20 to 100, and perhaps more pounds pressure per square inch. True, such application is not always direct, it being very frequently applied to heating the water in association with the "Baker" heater, or other and kindred appliances. But that steam heating on cars is not an unmixed blessing, goes without saying; for, not to speak of the familiar "too hot," and again "too cold," experiences—nor to dwell on the "pounding" and "chugging" incidental to the operation of some systems in particular, and the many and strange devices discovered and heralded as the panacea for such disorders—there is the undeniable fact that it costs appreciable money to heat cars, besides entailing a severe drain on the locomotive. The writer ventures to say that but few large cars are heated, in zero weather, with less than four boiler horse power per car; quite sufficient to

be a serious tax on the locomotive hauling a heavy train, and a point well worthy the thoughtful attention of superintendents of motive power and other interested ones.

Despite the thought of some very obvious, but not insurmountable difficulties, trains may yet be equipped with some such system as that herein indicated, and that where now the heating of cars involves a cost for fuel and water, more satisfactory and less costly results will be attained by the use of exhaust steam from the locomotive. Under such conditions there would be the advantage of returning some of the engine's condensed steam to the tank; also the further advantage of less scale in the boilers, with all that this implies relative to boiler efficiency, and longer service before retubing is necessary.

PRESIDENT SCHROYER: Mr. Scott, do you know of any such schemes now being employed as those to which you refer in the last clause of your paper?

MR. G. W. SCOTT (Pullman Palace Car Co.): Some of the Westinghouse people, under the name of the Standard Car Heating and Ventilating Company, manufactured a steam heating apparatus for railway cars. The system included a train service pipe, located, as usual, underneath the car bottoms, for the purpose of conveying live steam from the engines to the heating pipes within the cars. In direct association with the heating pipes, another train pipe was used for the purpose of conveying the water of condensation back to the engine, where, by means of a syphon or ejector, the water was delivered into the tank.

An almost similar system is now in use on the Pennsylvania trains; but, instead of using a syphon or ejector, as in the previous case, the water of condensation is removed and delivered into the tank by a steam pump usually located in the forward baggage car.

I have no knowledge concerning the operation of the former system; and, with reference to the Pennsylvania method, I understand the aim is to use steam at about 10 lbs. pressure per square inch.

It will be noticed in passing, that both systems referred to were designed and arranged for the use of live steam from the boiler, and not for exhaust steam from the engine.

MR. A. M. WAITT (L. S. & M. S. Ry.): I think that, by using live steam at very low pressure, the Pennsylvania has for some time been using a return system, using a vacuum pump on the tender, and I think has had some very satisfactory results. The principal difficulty, I believe, has been in keeping the pump in good working order. If it were not in good working order, the system would

prove a failure and it would be necessary to use high pressure steam in order to get the circulation through the pipes.

MR. J. N. BARR (C., M. & St. P. Ry.): Mr. Chairman, we have given this matter a great deal of attention and we have stopped trying to regulate the heat that is obtained from the steam radiators by regulating the pressure of the steam. We have a shop 400 feet long, with the main steam pipe in the center and four pipes on each side leading along the sides and dropping to the radiators; each alternate radiator is connected with the main branch pipe. With four valves on the main pipe, we can cut off one-quarter, two-quarters, three-quarters or four-quarters of the radiating surface. In other words, to regulate the heat we cut off radiators; we do not attempt to regulate by reducing the pressure, because, as the paper says, the difference of temperature due to difference in pressure amounts to practically nothing. If it is possible to get the steam into the pipes at one pound pressure, and through the pipes at one pound pressure, nearly as much heat will be radiated as would be radiated at twenty pounds pressure.

This arrangement we find gives much satisfaction—the only valves to control the flow of steam are the four mentioned, and these are sufficient to control the temperature in any large shop. We can cut off the radiators on one side of the shop, or we can cut out each alternate radiator on one side, or we can cut out each alternate radiator on a quarter section. This arrangement gives us perfect control of the amount of heat radiated and has worked very satisfactorily. We are using exhaust steam very successfully in that system of piping and without using a vacuum pump, but we find it is necessary to put automatic air valves on radiators in order to get rid of the air. I am of the opinion that automatic air valves would be found to be of immense benefit on heating pipes in cars. The difficulty with train pipes is to push the air out of the way and this cannot be done without the use of air valves. Were it possible to get rid of the air in the pipes the steam would circulate at one pound pressure through the whole train without any difficulty, I think, and heat the train to a comfortable temperature. A system which will provide against air being in the pipes will provide against water also, whether or not a vacuum pump or return connections are used. I mean to try such a system this year, and I hope somebody else will, too.

The use of the vacuum pump, as I understand the Paul system of heating, saves the water of condensation and returns it to the boiler; in a shop system the same result may be obtained by simply using a return system, but to get the steam to circulate the air must be removed from the pipe.

MR. B. W. THURTELL (A. Metz & Co.): The subject of heating large buildings is one that cannot be considered in a general way for all buildings. All buildings are different and therefore require different treatment. We have lost sight of a great many things in heating buildings. I find a great many superintendents and engineers who, without knowing anything about a building, will say, "Well, we will put in so much pipe, the main to be of a certain size." They make such decisions without knowing the wall space, the number of windows and doors, etc.; the result is that in extreme cold weather it will be found that sufficient radiating surface has not been provided to properly heat the building. It is very easy in mild weather to cut off radiating surface, but if there is not enough radiating surface, no matter how much steam there may be, it will not be possible to heat the building. By using the exhaust gravity return system, the use of the steam is obtained the second time. I was in a building last winter where the temperature of the water of condensation, going back from the building, was 211° F; the building was heated with the latent heat and the vacuum in the air valves was about 15 inches. Such results were not obtained by guesswork. In the first place there was taken into consideration the number of windows, and it was considered necessary to provide one square foot of radiating surface for every two square feet of window surface; to this was added one square foot of radiating surface for every 20 square feet of wall surface and one square foot of radiating surface for every 200 cubic feet of space to be heated; the sum of these three items gave the total radiating surface to be provided, and will be found sufficient to heat the space to a temperature of from 70° to 72° F.

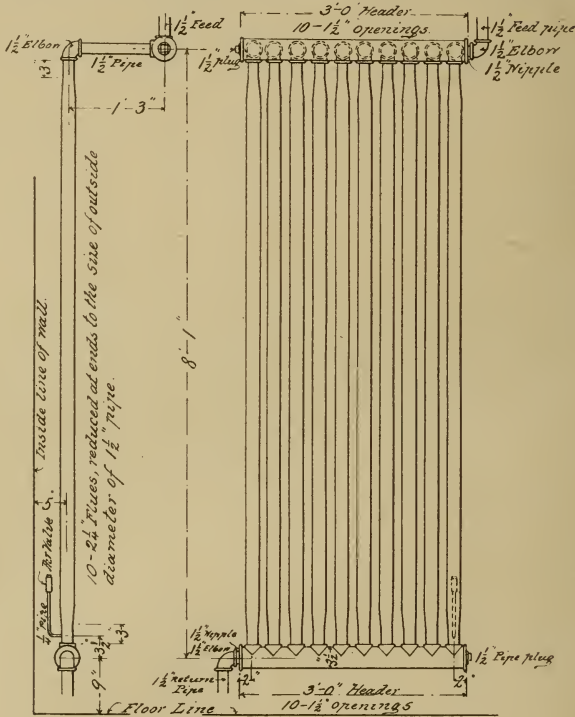
After obtaining the amount of radiating surface required, the next thing is to obtain the size of the main. For low pressure work divide the number of square feet of radiating surface by 100 and extract the square root of the quotient and the result is the diameter of the main required, approximately. I have never seen a failure where the piping was arranged according to the above rule. Of

course, the location should be considered, but the results are satisfactory for conditions met with about Chicago. The pipe leading from the main to a riser should be one size larger than the riser, the better to provide for the condensation returning to the tank and to prevent hammer blows.

MR. A. E. MANCHESTER (C., M. & St. P. Ry.): As has been said, the conditions and arrangement of each plant should determine the method to be employed in heating the plant. This is especially true, I think, in railroad shop plants. While I am a firm believer in the use of exhaust steam as a heating agency, I think that there must be taken into consideration to what other use the exhaust steam might be applied, and also the number of hours per day the steam is to be used to maintain the maximum temperature in the buildings, and how many hours per day the engines or pumps which supply the exhaust steam will run. In locomotive shops especially, on account of their proximity to the roundhouse where large quantities of hot water are required for boiler washing purposes and for numerous other uses around the plants, it may be possible that the exhaust steam can be as well, or better, utilized to heat water than to heat buildings.

I believe that one of the important features in connection with a good steam heating system is the arrangement of the piping and the radiating coils. We frequently find shops where, no doubt with the idea of economizing space, the radiators are located against the walls and then covered with benches or other obstructions, so that there is no opportunity for the cold air to circulate to the radiators and no way for the hot air from the radiators to be forced out into the room. In trying to get away from those difficulties at West Milwaukee we located our radiators along the wall and then moved out all obstructions, benches, tools and everything else, a distance of from four to eight feet away from the wall, making our trucking space for the handling of the material through the buildings in this space; the result has been very satisfactory. We also made a radiator, and, by the way, in this as in everything that we undertake at West Milwaukee, we tried to get our scrap pile reduced, so we made the radiator partially out of scrap. The radiator is shown in Fig. 1; it is a 10-manifold pipe radiator, the pipes being vertical, with the idea of giving the freest action for the return of the water of condensation back to the return mains. The radiator is made from

worn out 2 1/4-inch tubes, and the cost for producing the vertical pipe for the radiator was, taking 100 pieces of pipe to get the cost:



STEAM HEAT RADIATOR

For assorting and handling into shop.....	\$ 3.12
Annealing.....	.80
Cutting to length.....	1.20
Straightening and cleaning.....	.70
Swaging, scarfing and welding.....	5.46
Cutting 200 short pieces of 1 1/2-inch gas pipe.....	.60
5 per cent. for supervision.....	.59
Total for labor.....	\$12.47
For material, 1,600 lbs. old flues at 35c per cwt.....	\$5.60
50 feet 1 1/2-inch gas pipe, at \$3.56 per foot.....	1.78
50 gallons fuel oil for welding.....	.80
Wood for annealing.....	.50
Total for material.....	\$8.68

or a total cost for 100 pipes, which would be enough for ten radiators, \$21.15. The pipes are made by swaging the flue down to the size of a 1½-inch pipe and welding into each end a short piece of 1½-inch pipe upon which the thread is cut. Had we used 1½-inch gas pipe for making the vertical pipes, the cost would have been, for 100 pieces 8 feet long:

800 feet 1½-inch pipe, at .356c per foot.....	\$28.48
For cutting to length.....	1.20
Total.....	\$29.68

The prices that I have given for the above scrap and material were taken some months ago, and may not be the correct market price today. In the case of the 1½-inch pipe, it is estimated that the cost of cutting to length would be the same as for flues, \$1.20, but no charge is made for handling or for waste in cutting the pipe, which could only be estimated, and is, therefore, left out of the account. There would be in the ten vertical pipes of a 10-pipe radiator made of 1½-inch gas pipe 39.79 square feet of radiating surface, while in the same number of old flues the radiating surface would be 46.20 square feet, the 1½-inch gas pipe having but 88.29 per cent. as much heating surface as the flues, while the cost of the 1½-inch gas pipe would be 30 per cent. more than for the old flues.

As is shown in the paper, steam at 212° F. contains per pound of steam 1,146.6 total heat units from 32° F., and steam at gauge pressure of 5 3-10 pounds contains 1,151.5, or ½ of 1 per cent. more heat units. It is plain that only little effect will be produced in the amount of heat available for heating the building by increasing or decreasing the steam pressure in the steam pipes; the amount must be controlled by adding or cutting off radiating surface. This brings up another item of considerable importance in connection with steam heat—that is, controlling the amount of radiating surface. The method adopted at West Milwaukee is to run two lines of steam or exhaust mains for each line of radiators, each main to be connected to every other radiator; then if a change in the amount of heat is desired, the amount of radiating surface is easily manipulated by the valves in the mains. We find this a very satisfactory means of controlling the heat, and more satisfactory, so far as maintenance of controlling valves is concerned. As referred to in the paper, where the exhaust system is used, a back pressure

valve to allow free escape of all pressure above the desired amount is required. We have a very satisfactory arrangement for dispensing with the back pressure valve when a back pressure of not more than five or six pounds is desired, by submerging one end of the exhaust mains in a pool of water; the depth to which the pipe is submerged in the water determines the back pressure it will carry. The advantage in this method is that it never gets out of order, and any surplus exhaust that escapes into the pool can generally be utilized in the heating of water for other purposes.

I am of the opinion that while there are general rules that must be considered in the installation of any steam heating plant, each particular plant has local conditions and requirements that must be worked out for the individual plant. The paper refers to the question of returning the condensed water to the boilers. I presume that in all cases of this kind, the water is passed through a heater, or some device that has an oil extractor, as this would seem to me to be essential. The question is also referred to in the paper about the destruction of the pipes. It seems to me that the form of the radiator and the method of applying the pipes, as referred to by Mr. Barr, has a great deal to do with the life of the pipes in the radiator. I think that the exhaust steam is less destructive than live steam, although I have had no experience to prove it. It seems to me that the oil which passes through the radiators with the exhaust will have a good effect in preventing corrosion in the pipes.

MR. A. M. WAITT: I have noticed that in the discussion so far, only such systems of shop heating have been considered which obtain the heat by direct radiation from the steam in the pipes. I have noticed in visiting quite a number of shops in recent years, that many of the more modern shops, railroad shops as well as others, are heated with a system that combines together ventilation with heating, using in most cases, I believe, exhaust steam, but heating air and forcing the hot air through large conductors and distributing it under a slight pressure, not near the windows or doors where it is going to be chilled at once, but near the center of the shop, where it can go down and be thoroughly distributed about the shops, thus providing fresh air, at the same time warm air. It seems to me, in considering the economy of the two devices (I have no figures and do not know how they compare, but from the standpoint of efficient results in the way of good ventilation and good, equally distributed

heating) that that system has great advantages. I think there are representatives of some railroads here to-day who have had considerable experience with that kind of ventilation, and, if I remember rightly, some of the shops of the Illinois Central at Burnside are heated that way. I have noticed in going into those shops that the air seemed more pure and fresh than the air does in shops heated by steam pipes and with windows and doors closed. Often we notice in cars that are closed up, and in rooms where the air is not frequently renewed that after a while the air becomes foul, and people in the car or room do not feel as active and lively as they do when they are breathing pure air. I would like to know something of the experience of gentlemen who have been using this system of ventilation.

MR. MANCHESTER: I want to add one thing which I did not mention. The paper refers to the back pressure valve in the main pipe; we have the best back pressure valve obtainable. We have found that by running one end of the exhaust pipe into a pool of water a perfect back pressure valve is obtained, and the back pressure required is obtained by varying the depth of the end of the pipe below the surface of the water. It is possible to obtain any pressure up to about five pounds, which would probably be as deep as it would be convenient to have a pool; then all the steam that is wasted through the back pressure valve, if you call it so, is utilized by heating water for other purposes.

PRESIDENT SCHROYER: Do you use exhaust steam, or steam directly from the boiler?

MR. MANCHESTER: We use exhaust steam in that system.

MR. J. W. LUTTRELL (Ill. Cent. R. R.): The Illinois Central shops at Burnside are heated by the Sturtevant hot air system. The exhaust steam from the various engines is carried into heating pipes around which the cold air is drawn and heated and distributed through the shops through overhead pipes. During the summer months when the weather gets extremely warm the exhaust steam is cut out of the coils and the fans run for the purpose of agitating the air in the shops. I find the temperature in the building when the fans are running in the summer is from 3° to 4° lower than when the engines are shut down. The exhaust steam, after it is carried through the pipes and condensed, is carried back to the boilers by automatic pumps. This water is first deposited in a hot

water heater, from there into the force pumps, from the force pumps back to the second hot water heater, and from there into the boilers. By a test we found that the water was going into the boilers at about 40° F. below the boiling point. Since putting in this system and carrying back all condensation to the boilers we have found that we accomplish a saving of .8 tons of coal per hour. We have over-pressure valves in the exhaust pipe to take care of pressure when it gets above a certain point. We find no difficulty in taking care of exhaust steam except in extremely warm weather. We find that the water supply for our boilers is supplied by the condensed exhaust steam, plus about 8 per cent. more, which is drawn from our tank supply; our only loss in water being from trying gauge cocks and blowing whistles.

MR. G. W. SCOTT: I am inclined to think that the blower system, with its associated engine, blower, coils and hot air ducts, is more expensive than the installation of direct heating pipes. However, in passing, it may be noted that one-third of the amount of piping required for a direct system of heating will be sufficient for the coils in a blower system, other things being the same. The reason for this difference is due, of course, to the fact that in the blower system the air is forced, or drawn, through the space about the coils, and in this way becomes more generally heated than is possible in the direct system, where heating is dependent on the movement of the mass of air within the building to the coils placed, usually, along the lower part of the wall. At the same time, we should not lose sight of the fact that the blower system usually involves the question of either a steam engine, electric motor, or other power for its operation; and this, of course, occasions an item of cost for operation and maintenance.

Mr. Luttrell, in referring to the fan or blower system at the Burnside shops, spoke of the advantage of being able to afford a circulation of cool air in summer; and he rather intimated that the temperature of the air was somewhat reduced by the process of going through the fan or blower. Two of the large shops at the Pullman works are heated in a similar manner to those at Burnside; and, during the warm days of summer, the fans are operated as Mr. Luttrell describes. However, I think the sense of comfort to the men is occasioned rather by the circulation of the air than by any fancied or even realized lowering of the temperature. It is, in fact,

the manufacturing of a breeze where, otherwise, there would be the depressing influence of a still and humid atmosphere.

In referring to the system of heating at his company's Milwaukee shops, Mr. Barr spoke of the difficulty in removing the air from the pipes, and he mentioned the application of automatic air valves as affording some relief. Some valves may afford relief in the direction stated; but the escaping air is so heavily charged with noxious odors as to render their use very undesirable. One of the primary advantages in the system to which I have called attention, is the ability of the vacuum pump and the associated thermostatic valve, to successfully cope with the difficulties of the entrained air and water; and in so doing there is a complete absence of annoyances of any kind. If I rightly understood Mr. Barr, he intimated that the use of the vacuum pump was associated with the "Paul" system. This, I believe, is not the case; the Paul system being entirely dependent for the removal of air on the services of a steam actuated exhauster.

With regard to the President's query concerning the difference, if any, between horizontal and vertical heating pipes: The matter of radiation is dependent on the amount of exposed surface and within ordinary limits, other things being the same, similar results will follow whether horizontal or vertical pipes are used in the heating coils.

In reply to Mr. Marshall's question, I may state that the steam hammers at the Pullman works exhaust into what is known as the "exhaust cross connection." This is neither more nor less than a system of piping for receiving the exhaust steam from its various sources, and from which it may be diverted in the direction of its farther usefulness.

MR. G. W. RHODES (C., B. & Q. R. R.): Mr. Chairman, this paper is, I think, an exceedingly interesting one, especially to the master mechanics who have old shops in use and therefore old heating systems, but if I had seen Mr. Scott before he presented his paper, I would have suggested changing the opening paragraph so as to read as follows: "In many instances railroad managers, general superintendents and other persons in charge of power stations, shops and plant equipment generally, are so engrossed with the exacting cares of their onerous duties, that but little time is at their disposal for any attempt at investigation concerning matters not directly in the line of their immediate pursuit." I would not place

the responsibility on the superintendents of machinery, nor on the master mechanics; I would place it somewhere else. The reason for this is, that once a shop is equipped with piping and boilers for heating, it is exceedingly difficult to get any authority to make any changes, and I think the reasons are all given in the first paragraph as I would change it.

There is a feature of Mr. Scott's report to which I wish to direct attention. Mr. Scott says: "This, indeed, is a natural result, seeing that the corrosion of iron by the action of water is somewhat dependent on the degree of temperature, as well as the volume of water coming in contact with the surface of the metal." It seems to me here is a very important matter for master mechanics to consider when using high pressures and high temperatures in districts supplied with lime water. The heating of shops with exhaust steam necessitates, of course, a low pressure in the pipes, but the exhaust steam is available only when the engines and pumps are working; during the night the plant must be heated with live steam, probably with high pressure. Those who have heated their shops with steam in that way, in the lime districts, are well aware of the difficulty we have in the rapidity with which pipes give out, and the pitting and corroding of pipes and condensers has puzzled many mechanics. It looks to me a little as though Mr. Scott has hit upon a remedy, viz., that low pressures should be carried in lime water districts.

I would direct attention now, particularly, to the fact that locomotive boilers in use in districts supplied with water which is heavily charged with lime must be watched much more carefully when carrying from 200 to 240 pounds steam pressure than were the old boilers when carrying only 140 pounds steam pressure. I believe this is a very important matter. In conversation yesterday with my friend, Mr. J. N. Barr, he told me he had found that locomotive boilers carrying high pressure were corroded more rapidly than the boilers carrying lower pressure.

PRESIDENT SCHROYER: Mr. Manchester, what is your idea in setting your pipes vertically, instead of horizontally?

MR. MANCHESTER: I think they last longer than if placed horizontally, and furthermore, in the particular construction of our walls it is very desirable to place them vertically so that they can be placed between the pilasters which are only a few feet apart.

PRESIDENT SCHROYER: I would like to ask Mr Thurtell

whether, in figuring on radiating space required, any distinction is made between horizontal and vertical pipes?

MR. THURTELL: They are considered of equal radiating value.

PRESIDENT SCHROYER: Is it not a fact that the horizontal pipe located near the floor, gives the best results in heating?

MR. THURTELL: I do not know about that. Pipes will radiate a certain amount of heat whether placed vertically or horizontally.

MR. MANCHESTER: I would say further in reply to the question raised by the President, that on either side of a pilaster in our shops there is a window, and the vertical coil is set so that it covers half of this window. In cold weather the cold air from the window has a free circulation through the vertical coils of the radiator.

RECESS.

PRESIDENT SCHROYER: The first order of business, gentlemen, is the discussion of the subject, "Economy of, and limitations in, running locomotives long distances." Mr. Mackenzie has kindly consented to open this discussion.

MR. JOHN MACKENZIE (N. Y. C. & St. L. Ry.): In order to start the discussion I will refer to a remark that I made some time ago in regard to running locomotives long distances; do not wash out the boilers. I believe that will be the solution of the difficulty. I am going to make some radical statements in regard to that point and some which may not suit some of the members of the Club. We run locomotives, not long distances without turning, but although turning at distances of 116 to 141 miles we, nevertheless, get a large monthly mileage, and in doing so wash out the boilers once for about every 8,000 miles. This has passed beyond the experimental stage; we are satisfied that it is the right thing to do. There are a great many other things to be taken into account besides the question of washing out—one is the management of flues, and another the method of handling water in the boiler and the method of getting rid of the sediment. We some time ago undertook to say that the practice of swaging tubes was wrong; that in swaging, the iron was hammered out, crystallized and ruined. We do not handle the tubes this way now; we do not swage our tubes at all; they are applied two inches in diameter, and I think that the decrease in the width of bridge is not a serious matter. We do not scarf the tube; we do not butt-weld, but we simply expand the piece large enough to allow the tube to enter, putting the two butts together with the proper taper but full

thickness on the ends. We think we get a great deal better job in that way than we do otherwise.

I think there is no economy in running locomotives long distances. I am satisfied that an engine can run only so far without having the ash pan thoroughly cleaned and the fire cleaned, the distance depending on what kind of coal is used. It is a question whether it is cheaper to burn grate bars costing \$40.00 a ton, or coal at \$1.00 a ton. We all know what a dirty fire means; it means dirty smoke and cinders over the train; it means a great many things, the cost of which cannot be estimated. Running an engine a distance of 150 miles is all that should be expected without building a new fire, and when this is done all the mileage possible can be obtained and insure proper care. I have heard some people speak of running engines three or four hundred miles. I believe there is no economy in that; if the cost for the first and last 100 miles are compared, the latter will be found to be much the greater. We do not find any trouble, however, when turning our engines after 125 to 150 miles, to make with freight engines a mileage of five to six thousand, and with passenger engines seven to eight thousand miles a month.

MR. MANCHESTER: I am very much disappointed in what Mr. Mackenzie said. He has told us that he could run his engines 8,000 miles without washing out, but what I expected him to say to us today was that he had discovered that he could run his fires 8,000 miles without cleaning the ash pan. If he can do the latter I would feel that something in the right direction had been accomplished. I do not know that Mr. Mackenzie ever explained fully how he runs locomotive boilers 8,000 miles without washing them out. We have water along our system which would leave more than one boiler full of dirt as the accumulation of a run of 8,000 miles. I remember that an engineer came in once and said, "The boiler is getting dirty." I asked him why he thought so, and his reply was, "It takes such a small amount of water to show from two to three gauges that I am sure the boiler must be nearly full of mud."

MR. MACKENZIE: There seems to be no one anxious to tackle me but Mr. Manchester. Mr. Chairman, there are many things necessary to be done to keep boilers clean, and they must be kept clean if they are to make long distances without being washed out. We have a system, a requirement rather, which may be called a

system, the conditions of which are that engines going into a terminal must have full steam pressure allowed and a good, clean fire, or a fire as clean as is possible after a run of 140 to 150 miles. The locomotives are switched onto the coal track where the fire is to be cleaned. Just as soon as the engine stops, the man in charge of the engine opens the surface blower; the water is supposed to be at the normal height for the surface blowers, and he is supposed to hold the blowers open for, say, fifteen to twenty seconds. While he is washing he watches the gauge, and when there are indications that all the sediment has settled, he opens the blow-off cock. That is the washing out that we give the boilers. The surface blowers or blow-off cocks are not opened at intermediate points if it can be avoided; we say that is a waste of water. The locomotives can be brought in with a clean fire; the surface blowers and then the blow-off cocks can be opened for some seconds each and no more washing out is required. "The proof of the pudding is chewing the string;" we are satisfied with the daily reports that we get while handling our locomotives as described; whereas, some two years ago, before we started the present method, reports would come in from the roundhouse. "One inch of mud on the mud ring." Now the reports show the same amount of mud after running 6,000 miles as formerly accumulated on a run of 400 miles.

A MEMBER: I would like to ask Mr. Mackenzie if he uses any settling tanks to get rid of the sediment?

MR. MACKENZIE: There are two stations on our road where water is obtained which is supposed to be bad and where we use auxiliary tanks for settling. We thought the only method of purifying water was to do so before putting the water into the tender, and after a good deal of experiment we found that there was a great deal of trouble caused by using this water after putting in the necessary amount of soda ash as required by the chemist; today, I think, we are putting in but very little soda ash, but quite a little lime in our tanks. There are only two places where we use it. Of course it was a great help to us, but that is all.

MR. RHODES: Can we hear from some of the master mechanics as to what they think of Mr. Mackenzie's idea of running a large number of miles without washing out, using blow-off cocks instead? I would like to know for my own information what they think.

MR. J. F. DEEMS (C., B. & Q. R. R.): I expressed myself quite

freely at the time Mr. Mackenzie brought up this subject before, and took occasion to support him at that time. I have had no reason to change my mind in regard to the matter since that time. I believe it is quite possible to run engines much farther than at present without washing out. Whether we reach the limits named by Mr. Mackenzie or not, I do not know, but I believe the farther we can run our engines without washing them out, but by using blow-off cocks, and the more continuously we can run them, the better it will be for the tubes.

I cannot agree with Mr. Mackenzie when he says that the short runs are as advantageous as the long runs, for the reason that it is difficult to get a time card at all times that will make it possible to get the mileage from the engines on short runs; they cannot be turned quickly enough. I know of a case of recent date where an engine with a passenger train ran 350 miles; I made an investigation and found there had been no trouble on account of fire box filling up, nor for want of steam. If it is possible to run such distances then the mileage can be obtained regardless of the time card. I still feel as I did a year ago when this subject was up, that if more attention were given to the matter of running engines farther between times of washing out, and to using some proper system of blow-off cocks and surface cocks, there would result a great saving.

MR. RHODES: I am interested in what Mr. Deems has just said because it seems to me a big improvement if possible, if engines can be run as far as Mr. Mackenzie says, through districts where there is not very good water, without washing out; but it does seem to me that, if this can be accomplished, we surely ought to be able to run an engine at least 250 or 300 miles without having any trouble from a dirty fire box or a dirty ash pan. What is needed is some intelligent care in designing and constructing the fire box, and in designing and constructing the ash pan, to make possible a run of 8,000 miles before it becomes necessary to wash out the boiler.

It is well recognized that the reason railroads were first constructed with the 100-mile division limit was largely because the fire box and the ash pan got so dirty running that distance that it was impossible to get any farther with any degree of success. The question now is how to improve the fire box and the ash pan. One way is to make the ash pans twice their present size, thus providing a receptacle sufficiently large to keep the ashes away from the fire box

and the grates. Another way is to construct the ash pan in such a way that, without any difficulty; the fireman can clean it while he is stopping at stations. I would say that, undoubtedly, long runs are economical, and these long periods between times of washing out, which Mr. Maekenzie advocates, makes long runs still more practicable.

I recollect that some time ago, with our consolidation engines having long, shallow fire boxes and inconvenient grates the delay, especially in the winter, in cleaning out the fire boxes and the ash pans was quite serious, and a well known railroad manager said to me. "The most important thing with these big fire boxes is to devise some means by which they can be quickly and promptly cleaned out, so that there will be no long delays at terminals in turning the engines around." Since then this question has been up with many railroads, and improvements have been made, and now certain railroads will not run engines with big fire boxes and ash pans, unless they have convenient methods for cleaning out the fire box and for cleaning out the ash pan, which do not require the fireman to crawl underneath the engine. I think that if we should consider a little, we would understand better the economy in the number of engines to be used by having a 200-mile stretch in place of the former 100-mile stretch. What do the men in the motive power department do when a railroad goes into the hands of a receiver? About the first thing is to lengthen out the locomotive runs, double up the runs of the engines and close up the nucleus of shops that mark the old 100-mile run; by saving power and closing up these shops and extending the runs, they bring about an economy which the previous managers have not been able to attain. I believe thoroughly that if the railroads of this country had to be built over again, that in place of having divisions 60, 70 and 100 miles long there would be divisions 200 miles long, and in place of a nucleus of a shop every 100 miles or more frequently, we would have a nucleus of a shop every 200 miles. I am a thorough believer in long runs, and I believe that it is the most economical method of handling trains.

PRESIDENT SCHROYER: Mr. Rhodes, what do you think is the limitation of those long runs?

MR. RHODES: That I am not quite prepared to say. In marine service the vessels run continuously, they are never stopped to rest the machinery, nor are the vessels run as we run locomotives.

Recent practice has shown that on these long runs the men give out first. The latest practice has brought about changing of men, not the changing of locomotives. I believe that one reason why long runs are not indulged in more frequently is because the whole road system is adapted to short runs. For instance, engines must take coal. The old system of taking coal on an engine is to take it at the roundhouse at the end of the run. Now if a road is divided up into 100-mile divisions with coaling stations at the end of each division, and if it is desired to run 200 miles with the speed that the trains are now making, it is impossible to take the engine from the train, run to the roundhouse to coal and then bring it up to the train and go on; to make it successful it is necessary to coal on the line of the road, and also to take water on the line of the road. With suitable facilities for taking coal and water on the main line, I think, probably, what would limit the length of run of the engine would be the washing out, as indicated by Mr. Mackenzie.

MR. MARSHALL: It seems to me that Mr. Rhodes' statement that the men constitute the limit on long locomotive runs is right; the final condition of the fire forms another limit. On the North-Western, in Iowa, we have one run of 200 miles for both passenger and freight. We have no trouble with this length of run for the passenger trains, but on freight trains, occasionally the men give out. These engines which make 200 miles successfully have very dirty fires when coming into the terminal if the coal is at all bad, and I have seen a fire on shallow fire box engines that was right up to the door, the fire being a foot deep. I do not see how it can be avoided with the poor coal that we sometimes get. The ash pan does not give trouble; it is the dirt on top of the grates and not underneath them. We have begun to experiment with one device, gotten up by a fireman on our line, which consists of a combined clinker hook and tongs. We have not yet used it enough to say very much about it, but this fireman and others on the division where he was located have used it successfully, and it is claimed that by its use an engine can be brought into a terminal with fires almost as good as when starting out. We have recently made quite a number of these tongs at our Chicago shops, with the idea of putting them on one division and giving the device a thorough trial.

MR. MACKENZIE: Mr. Rhodes said something about the number of engines required to do a certain amount of work; three years

ago, I think, in my annual report I recommended buying twenty-five freight engines and ten passenger engines, because I thought we needed them. Time went on and those engines have not materialized, and the management said to me only a few days ago that, notwithstanding the fact I had repeated the request, we would not get any this year; that we had more engines than we had business for, notwithstanding the fact that the business had been increasing with us all the time. What has brought about such a condition? The fact that we have succeeded in getting more out of the engines we had. We used to think it was entirely satisfactory to get 2,500 miles a month out of an engine; now we are not satisfied unless we get from 4,000 to 6,000 miles a month out of an engine where the schedule is favorable to such service; the interest saved on the investment which it seemed necessary to make several years ago was quite an item.

By way of economizing in caring for engines and washing out the boilers, we have six stations on the line where boilers are washed out. There is a boiler washer and a boiler maker, day and night, at each point, twelve men in all; these twelve men were, previously, supplemented by twelve other men, boiler makers, helpers and washers, and when we started in with our new method we cut off every alternate boiler washer and every alternate boiler maker and his helper, so that today we have less than half of what we had two years ago in the way of skilled boiler makers and their helpers and boiler washers. The saving in this way alone was about \$27 a day; besides we make increased mileage with the tubes and also with fire boxes and boilers.

PRESIDENT SCHROYER: Is there anything further on this subject? We have another subject, and if there is no further discussion on this one, we will move on to the next subject, which is: "Is it practical, safe and economical to use spliced air brake hose?"

MR. A. M. WATT: Mr. Chairman, I was asked, since coming in the room, to open the discussion. Several years ago some of the roads centering at Chicago, I believe, started the practice of splicing air brake hose, and as the cars equipped with such hose went east, the practice of passing spliced air brake hose was looked upon with a good deal of doubt, and quite a little discussion arose in regard to it. Some of the roads took occasion to refuse hose that were spliced. There was quite a little agitation at the time, and the representatives

of the roads that were adopting the practice of splicing hose defended themselves. Two years ago, I believe, the matter came up in the noon hour discussion of the M. C. B. Association convention, and after considerable discussion at that time a vote was taken to get the opinions of the members on the subject, and without a dissenting vote a motion was passed approving of the practice as being safe and economical. The simple precaution taken was to require that the parts of the hose used for splicing should be in a condition as good as required for full length hose. At one of the meetings of the master car builders of the Lake Shore road we spent quite a little time discussing the pros and cons of this practice; the discussion took place after the vote had been taken by the Master Car Builders' Association, and it was finally decided that it would be wise to adopt the practice, and we have done so to a limited extent. We have had made a little malleable casting to use with the ordinary clamps, and we have been saving good parts of hose that were removed, and have spliced and applied quite a number. We restrict the application of the hose to our own train equipment, so that those who do not approve of the practice will have no occasion to raise objections.

It costs seven cents to splice hose; this cost includes everything—labor, two clamps, the bolts and the casting. We are careful in selecting parts of hose to reject those that are liable to give out soon. From a little investigation in regard to the average life of hose that are now in service and which have been purchased without any special specification, I would say that if any one were going into the practice of splicing, that they use only parts of hose that have not been in service over two years. I think it is not safe to take hose that has been purchased without any special specification, and that is over two years old, and attempt to splice it and get any longer life from it. There are two makes of hose in the country, that I have examined, and which have an average life of over twenty-four months, but the makers charge so high a price that a large number of the railroad companies think they can not buy such hose. That has been our experience, and it seems to me to be unwise to run the ordinary hose in service, or use them in splicing, at least if they are more than two years old. I think the practice of splicing hose is a perfectly safe one, provided the same pains is taken in splicing and putting up the hose that is taken in putting in a new hose, and if the hose is tested under a 100-pound pressure to make sure that the

work of splicing is well done. I think, perhaps, it is wise for roads to use spliced hose on only their own cars, so as to avoid disputes, until it is a more perfectly recognized practice. I hope that before long we will not have to depend upon renewing our hose on cars every two or three years. The expense is tremendous. It is hoped that some one will be ingenious enough to get up something in the way of metallic connection. The bursting of hose is rather alarming in extent. On the Lake Shore, practically all our cars are equipped with air brakes, and every hose that bursts in train service comes to Cleveland, to the general office, and a record is kept of the condition. You may be a little surprised when I state that on our road, with the air being used, as I believe, with ordinary care and efficiency, we have had from eight to ten cases of burst hose in train service per day. Now, if any one feels inclined to dispute the fact that there are so many cases, I would suggest that they make sure that every hose that is removed by trainmen or by inspectors on account of its giving out in service, be sent to the general office; I think they will be surprised at the result. I know that we have taken as good precautions as possible, and probably as good precautions as most of the larger roads have with regard to insuring good, efficient practice in handling the air brakes, having a competent air brake instructor, who not only instructs the men in the first place, but who spends the balance of his time on the road and on trains and in yards, checking up the work of the men and seeing that they handle the brakes as well on the road as they do when they pass examination in the car, and with all these precautions we have the experience which I have previously explained. By the way, the bursting of hose on the train does not mean that any serious damage results. Once in awhile there will be a case where there are quite serious results, but in the majority of cases there is no special harm done, except the delay and the necessity of replacing the hose.

MR. RHODES: I would like to ask Mr. Waitt whether, in these cases of burst hose, he finds that the bursting is always due simply to pressure within? My reason for asking is this: Some time ago we were investigating the matter of hose and hose failure, and we found that there was much negligence in the method in which the hose was applied to the car, and that a very large proportion of the damage to hose was done mechanically, and on account of this mechanical injury they subsequently gave out. It is my experience that a little

more attention on the part of those who apply the hose to the car would prevent that mechanical injury to the hose which afterward comes in handling the car. Has Mr. Waitt observed whether these eight or nine cases which come in daily are all due to bursting, or to a combination of mechanical defects outside and bursting inside?

MR. WAITT: I would say that last Saturday I made a personal examination of about 200 hose that had been removed, or sections of them, the sections being taken about six inches long, so that in each case the section included the part that failed. The hose was cut longitudinally so that it could be opened to disclose the condition inside. I do not know that I can speak accurately, but I should say that about 25 per cent of the hose that were burst showed that the bursting resulted, not especially from mechanical imperfections in applying the hose, but to some injury to the rubber or the hose; it was not due to any inherent defect in the hose. In some cases I found that the clamps had been put on so tightly that they had sheered the rubber on the outside, and then water coming in had rotted the canvas, and after a short time in service evidently the water had worked its way around through the canvas until it got to the top, and the hose burst. In a great many cases it was found that because the outside of the hose had been struck with the hammer, not only the cover of the hose had been bruised sufficiently sometimes to expose the canvas, but the bruise taking place at the bottom part of the nipple, the rubber inside had been bruised by the end of the nipple and in some cases punctured, and the air broke out that way. I have been making some little inquiry to see how such accidents occur, and I found that quite generally the angle cocks on the cars are very tight, very hard to move, and that inspectors will strike them with a hammer to turn them around, and sometimes they strike the handle in such a way that the hammer strikes the angle cock, and that bruises the rubber; at other times, a link or a pin used for a hammer slips off and goes down and bruises the rubber. It had been suggested that it would, possibly, be a very good opportunity to provide some device to put around the outside of the rubber, some metallic device, as a protection against such injury. A large percentage of the failures of hose occurred within two inches above or below the end of the upper fitting, and, apparently, many of the failures were due to misuse, a stroke from a hammer bruising the rubber and sometimes puncturing it; if something could be devised

which would extend down an inch or two beyond the edge of the fitting to protect the hose, I think there would be fewer cases of burst hose.

MR. RHODES: The metallic application that I am anxious to see railroads adopt to partly stop this injuring of hose is the buffer block. If we all adopt the buffer block, the hose will then be thoroughly protected.

PRESIDENT SCHROYER: The mechanical injury to which you refer in your remarks, does that refer to the bursting of hose by pressure?

MR. RHODES: No, I mean from whatever cause. Mr. Waitt describes it; our experience has been similar to his.

MR. WAITT: Regarding the injury done our hose by pressure: I was surprised to find that there were, probably, not three hose of the 200, the bursting of which I could in any way trace to any mechanical injury done by the fitting. I have found not more than three or four cases in which the clamps had been screwed on sufficiently tight to cut the hose.

MR. MANCHESTER: Our practice of handling spliced hose has been very similar to the practice explained by Mr. Waitt. All bursted hose are sent to West Milwaukee, and there a record is made of the defect that caused the hose to be removed from service. We have a list which gives location of defects, whether at either end or in the middle, and whether failure was caused by kinking or by a blow, or by a cut, or by a pull-in-two. In selecting pieces of hose to be spliced, the age of the hose is not considered; we depend entirely on the general appearance. As a rule, the ones that are used for splices are ones that have been damaged by blows or are cut. We follow the practice of applying them to only our own cars.

PRESIDENT SCHROYER: I think we are getting away from the subject. The subject is: "Is it practical, safe and economical to use the hose that are spliced?" not the cause of the bursting, nor the manner in which the splicing is done, but is it economical and advisable to use spliced hose?

MR. MANCHESTER: Our records show that at the end of our fiscal year ending June 30, 1898, we had in service on engines, and passenger and freight cars, 40,293 hose. The total number of failures from all causes during the year was 6,323. Of this number 2,766 were spliced and returned to service. It appears that the total

number of failures of hose was about 15 per cent. of the total number in service, and that the number of failures of spliced hose was about 14 per cent. of the total number of spliced hose in service. Our cost for splicing is about the same as that given by Mr. Rhodes and Mr. Waitt. We consider it economy, and also practical and safe to splice hose.

Our method of keeping record of the hose failures and the causes for which they give out is shown in the following table. Fig. 2 accompanying, facilitates explaining location of defects.

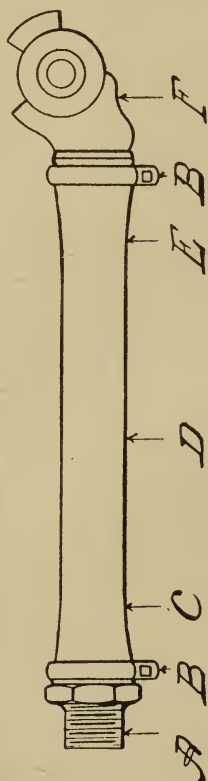


FIG. 2.

DEFECTS FOR WHICH AIR HOSE ARE WITHDRAWN FROM SERVICE.

- 1 Burst at C.
- 2 Burst at B.
- 3 Burst at D.
- 4 Cracks through rubber at C, exposing canvas.
- 5 Cracks through rubber at D, exposing canvas.
- 6 Cracks through rubber at E, exposing canvas.
- 7 Damage to nipple, A.
- 8 Damage to coupling, F.

NOTE.—Defects caused by kinks must be shown in column of figures in prime, thus 1², 2², 3², etc.

MAKER.	KEY.															Total	Returned for Replacement						
	1	1 ²	2	2 ²	3	3 ²	4	4 ²	5	5 ²	6	6 ²	7	8	9			10	11	12	13	14	15
	63	91	31	28	34	7	1	3	...	...	...	...	1	13	1	10	1	49	139	15	45	532	29
	172	235	58	96	149	30	3	18	8	10	8	...	3	53	3	3	3	10	196	706	79	219	2059
	17	11	2	2	7	21	3	8	...	...	...	...	1	3	3	10	1	14	26	4	15	113	...
Spliced hose...	58	126	16	25	27	21	3	8	3	2	...	...	...	17	3	3	...	2	119	899	56	265	1350
Miscellaneous	41	10	46	16	39	13	6	24	1	12	14	7	1	6	4	6	9	196	478	49	151	1868	...
	175	318	93	80	179	26	6	24	1	12	14	7	1	6	4	6	9	196	478	49	151	1868	...
Total.....	526	791	246	247	435	97	13	54	25	26	16	1	11	122	11	32	23	625	2109	204	709	6323	53

Number of hose spliced, 2,766.

EQUIPPED WITH AIR
BRAKES.

Locomotives.... 729
Passenger cars.... 771
Freight cars..... 16,782

Total..... 18,282

PRESIDENT SCHROYER: This subject was suggested in connection with the interchange of cars, the question being whether cars with spliced hose should be carded for or accepted without cards; no one has said anything on the other side of the question, as to whether it is unsafe to use spliced hose, or whether cars with spliced hose should be accepted in interchange. This is one important point of the subject.

MR. RHODES: Mr. Chairman, I will give some figures here, just roughly, to show what saving we are making on the Burlington road by using spliced hose. I consider that the man who has judgment enough to know when a second-hand hose can be used, has judgment enough to select pieces good enough to be spliced. We are using at Aurora 500 spliced hose a month which cost 7 cents each, a total of \$35.00. If we did not use spliced hose we would have to buy 500 pieces of new hose at 75 cents each, a total of \$375.00; therefore under the most unfavorable calculating we save \$340.00 a month. Now going back to the argument that was used at the Master Car Builders' convention some years ago, in '97, I think; the question was asked: What man is here who throws away a full length of fire hose on account of a burst; who throws away a garden hose because it bursts once; or who has a bicycle tire burst and throws away the bicycle tire? In every instance the hose or tire is repaired, and it does seem to me very remarkable that every railroad handling air brake hose throws away the hose when it bursts once. I want to be put down as answering your question very emphatically, that I think it is very safe, and that it is the best practice, to repair good second-hand hose by splicing.

MR. MANCHESTER: Another thing I want to say which is not absolutely in the line of the argument: Some years ago we made an effort to economize in boiler washout hose, and finally decided to wrap the hose with rope yarn; by so doing the life of our washout hose has been increased from two to three times what it was previously. It has occurred to me during the discussion of protecting the hose at the point where it is injured, whether such protection will not be better obtained in some way other than with metal shields, and whether it would be a better scheme to wrap hose with yarn to the point where the injury occurs.

PRESIDENT SCHROYER: The Chair will entertain a motion to

the effect that it is the sense of this Club that it is safe and economical to use spliced air brake hose.

MR. RHODES: I move, Mr. Chairman, that it is the sense of this meeting that it is safe, economical and good practice to splice and use good second-hand hose to be used in freight car service, and that such spliced hose should be accepted in interchange without card.

In offering this motion, Mr. Chairman, I agree with Mr. Waitt and Mr. Manchester, that the use of spliced hose is likely to produce less trouble if such hose is not applied to foreign cars. We use spliced hose on only C., B. & Q. cars.

The motion made by Mr. Rhodes was put to vote and carried.

PRESIDENT SCHROYER: We have with us today Mr. T. L. Toriyo, who is Minister of Agriculture and Commerce of Japan. Mr. Toriyo will not address the meeting, but I know that he would be very glad to meet all of you personally, and I hope that you will be in no wise backward in introducing yourselves to him, or those who know him in presenting him to other members who are not acquainted with him.

We have with us, also, Mr. William Thow, chief mechanical engineer of the government railroads of New South Wales. I know that we will all be glad to meet Mr. Thow, and that the Club will be pleased to hear a few remarks by the gentleman.

MR. THOW: Mr. Chairman and Gentlemen—This takes me by surprise, but still it is a pleasure to which I am only too glad to respond. I came to this country to pick up information, and as far as I have gone I have met with a number of friends who have been very ready to grant it to me, and I shall be able to go back to Australia after a while to make use of the experience which you are enabled to exchange with each other in a way which we in Australia cannot expect to do. Australia is divided into four or five sections, and as the capital of each is considerably isolated from its nearest neighbor, such meetings as this never, or very seldom, occur with the railway men there. The distances are too great, and I may say that the duties imposed upon the railway men are so considerable that the time is scarcely available for holding meetings in different capitals very frequently. Sometimes we have them, perhaps once every two or three years, but that of course is not the object of such a meeting as this. Therefore, we suffer from the lack of interchange

of ideas which you secure by holding your club meetings as frequently as I suppose you do. It is at an opportunity like this that you hear very valuable information. The experience of other men working in certain directions and grooves which is made common information and common property to all should be appreciated. I should be very glad indeed if we could follow out the same course in Australia, but that is not possible just now, with our isolated condition. This club meeting is very much like what we have in England. Before going to Australia I had the advantage of attending some of the meetings of the mechanical engineers and civil engineers, and it is one of those things that I have always felt, since leaving that country, to be a sacrifice to railway men going out to distant parts of the world. One may read the proceedings of such societies, but he does not get the interchange of ideas and he does not get that boiling down, as it were, of the subjects under discussion, which is really the valuable part of all such papers as you deal with here. I have to thank a number of the gentlemen present for the kindness that they have extended to me, and I shall go back to Australia with very considerable feelings of regard for the gentlemen that I have met in and about Chicago. (Applause.)

PRESIDENT SCHROYER: On behalf of the Club, I wish to thank Mr. Thow for his remarks. We, of course, can scarcely realize the great differences in the conditions as they exist in this country and in Australia, in so far as the railway world is concerned, and I question very much whether your people have much of an idea of the magnitude of the railway business in this country and the method of handling traffic by interchanging cars, one road with another. This is one of the objects which calls together the railroad men of the mechanical departments and causes them to exchange ideas, to adopt standards, and such uniformity of construction of cars as will simplify and facilitate the movement of traffic from road to road and from state to state. Under such conditions cars must be constructed in such a manner as to facilitate the repair and maintenance of foreign cars while on each other's lines, in the same manner and just as cheaply as we maintain our own. This one question, more than any other, has called forth the necessity of meetings of this character.

I wish to thank you again for your kindness in addressing us, and assure you of the pleasure of meeting you. We will all be glad to have you visit us at our places of business, and any information we have we will be glad to impart.

Adjourned.

LIBRARY ACCESSIONS.

The Trustees of the Library wish to acknowledge with thanks the following donations to the Library, received since April 25, 1898:

- Mr. Geo. S. Morison: Eight lithographs of drawings of various bridges.
 Mr. H. F. J. Porter: Paper on "Fatigue of Metals," read before Franklin Institute December 8, 1897. Pamphlet.
 Secretary of War, Washington, D. C.: Tests of Metals. 1896.
 Mr. S. F. Patterson, Secretary: Proceedings of the Seventh Annual Convention of the Association of Railway Superintendents of Bridges and Buildings, held in Denver, Colo., October, 19, 20 and 21, 1897.
 Mr. R. W. Pope, Secretary: Transactions American Institute of Electrical Engineers. Vol. XIV. 1898.
 Mr. F. W. Sargent: Proceedings of various railroad clubs, twenty-two copies of back issues.
 Mr. N. L. Litten, Secretary: Constitution, By-Laws and List of Members Western Society of Engineers. June, 1898.
 Department of the Interior, Washington, D. C.: Statistical Atlas of the United States. Eleventh Census. By Henry Gannett. 1898.
 Department of State, Washington, D. C.: Review of the World's Commerce during years 1896-1897. Washington, 1898.
 Mr. J. W. Cloud, Secretary: Proceedings American Railway Master Mechanics' Association. Vol. XXXI. 1898.
 Bethlehem Iron Co.: Evolution of the Modern Engine Shaft. By H. F. J. Porter. Pamphlet. 1898.
 Prof. W. F. M. Goss: Set of eleven lectures on railroad subjects, delivered at Purdue University and published in pamphlet form. 1898.
 Mr. John P. Meany: Poor's Manual of Railroads. Thirty-first annual number. 1898.
 Mr. L. F. McGann: Mayor's Annual Message and Twenty-first Annual Report of the Department of Public Works to the City Council of Chicago. For fiscal year ending December 31, 1896.
 Mr. E. A. Simmons: Universal Directory of Railway Officials (London). 1898.

THE DAVID L. BARNES LIBRARY.

SPECIAL NOTICE! The David L. Barnes Library of this Club, at 1750 The Monadnock, Chicago, is open for the use of members and their friends, and we hope it will be used freely. It is open on week days from 9 a. m. to 5:30 p. m., except on Saturday, until 3 p. m. Books must not be removed from the Library, but the librarian will assist visitors in finding information and will promptly reply to letters from out-of-town members desiring information from the Library. Donations of books and technical publications will be gratefully received.

TRUSTEES OF THE LIBRARY.

List of duplicate copies of the Proceedings of the Western Railway Club which are in the David L. Barnes Library and are for sale or exchange:

- 1888—Sept. and Oct. (bound in one).
 1889—Oct., Dec.
 1890—Feb., Sept., Oct., Nov., Dec.
 1891—Jan., Mar., Apr., May, Oct., Nov.
 1892—Jan., Feb., Apr., May, Sept., Nov., Dec.
 1893—Two complete volumes; also single copies of Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.
 1894—Jan., Mar., Apr., May, Oct.
 1895—Jan., Apr., Sept., Oct., Nov., Dec.
 1896—Jan., Feb., Mar., Apr., May, Sept., Nov.
 1897—Jan., Feb., Mar., Apr., May, Sept., Nov., Dec.
 1898—Jan., Feb., Mar., Apr., May.

Correspondence relating to the Library, donations of books, periodicals, etc., for the files, or duplicates sent for exchange should be addressed to H. de K. Woods, Librarian, 1750 Monadnock, Chicago.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

(INCORPORATED.)

OCTOBER 25, 1898.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 2.

CHICAGO, ILL.

{ \$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Roadmaster, C., B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER.	JOHN W. CLOUD.
F. W. BRAZIER.	H. G. HETZLER.
PETER H. PECK.	F. W. SARGENT
PROF. WM. F. M. GOSS.	

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio

A regular meeting of the Western Railway Club was called to order at 2 p. m., Tuesday, October 18, 1898, in the Auditorium Hotel, Chicago. President C. A. Schroyer in the Chair.

Following are the names of those who registered:

Amory, E. P.	Green, Fred J.	Riddell, Chas.
Anderson, Geo. T.	Hatswell, T. J.	Roberts, S. W.
Angell, Frederick R.	Herr, E. M.	Robinson, Jay G.
Apps, W.	Hetzler, H. G.	Rogers, M. J.
Bates, Edw. C.	Hill, James W.	Royal, Geo., Jr.
Brazier, F. W.	Hooper, W. H.	Sanborn, John G.
Cardwell, J. R.	Jacobs, R. E.	Sargent, F. W.
Canfield, L. T.	Keeler, Sanford.	Sawyer, Edw. C.
Clark, F. H.	Kidder, S. J.	Scales, Richmond P.
Coleman, J. C.	Kilvert, M. A.	Schroyer, C. A.
Connors, James J.	Kirby, Tom.	Setchel, J. H.
Cooke, W. J.	Kissinger, V. T.	Smart, Richard A.
Crosman, Walter D.	Lane, F. W.	Smith, H. E.
Curtis, H. R.	Mackenzie, John.	Street, Clement F.
Cushing, Geo. W.	Manchester, A. E.	Tratman, Russell E. E.
Davies, W. O.	Molleson, Geo. E.	Waitt, A. M.
Delano, F. A.	Moran, Edw. L.	Widner, J. E.
Fildes, Thos.	Morris, A. D.	Whipple, A. L.
Furry, Frank W.	Otis, Spencer.	Whitridge, J. C.
Gardner, J. W.	Paxton, Thos.	Whyte, F. M.
Gasche, F. A.	Payson, Geo. S.	Wolfenden, J.
Goehrs, Wm. H.	Peck, Peter H.	Wood, G. S.
Goss, Prof. W. F. M.	Pratt, E. W.	Younglove, T. G.
Gowing, J. P.	Quayle, R.	

PRESIDENT SCHROYER: The first order of business is approval of the minutes of the last meeting; they are in the hands of all members who are in good standing, and if there are no corrections to be made in the minutes as published, they will stand approved.

The Secretary then read the following list of applications for membership, which had been acted upon favorably by the Directors:

Geo. A. Adams, Chief Clerk of Supt., C. & W. I. Ry., Dearborn Station, Chicago, Ill.

L. P. Breckenridge, Professor Mechanical Engineering, Illinois University, Urbana, Ill.

Ferd. G. Gasche, M. E., Illinois Steel Co., South Chicago, Ill.

Norman L. Hayden, Pres. Hayden & Derby Mfg. Co., New York City.

Wm. H. Huffman, Foreman M. P. D., C. & N.-W. Ry., Belle Plaine, Iowa.

J. E. Loy, G. F., C., R. I. & P. Ry., Goodland, Kan.

M. McKean, M. P., Foreman Grand Trunk, Elsdon, Ill.

J. H. Shea, Passenger Engineer Santa Fe Ry., Chicago, Ill.

W. T. Slike, Draftsman Richmond Loco. Works, Richmond, Va.
Wm. B. Throop, Div. Superintendent, C., B. & Q. R. R., Galesburg, Ill.
James Timms, B. M. J. & C. Co., Columbus, Ohio.
J. W. Treat, C. A. Treat Mfg. Co., Hannibal, Mo.

The President called for the report of the banquet committee.

SECRETARY WHYTE: Mr. President, the report of the committee is included in the notice for this meeting, and is that the committee decided that it was best not to hold a banquet this year.

PRESIDENT SCHROYER: At the Directors' meeting this morning a report was made by Mr. Sargent, chairman of the Board of Library Trustees, in which he furnished a statement of the disbursements and receipts of the Library Board for the year just past, and an estimate of the expenses for the present year, and asked for an appropriation to cover the latter. Until last June the expenses of the library were paid from a fund which was raised by subscription, but as it has been thought best not to continue such method the Board of Directors has ordered that the expenses of the library shall be paid by the Club in the same manner as other expenses of the Club are paid, and the Board of Library Trustees has been requested to keep the expenses within its estimate of, approximately, \$400.00. If there is any objection to be offered to this by any member we would like to hear it now. The *Railroad Gazette* continues its subscription by paying a part of the rent of the library rooms. The finances of the Club are in such condition that we feel we are justified in taking the action referred to. If the expenses of the Club and the library become too large to be met by the resources we may have to call on you for subscriptions for the maintenance of the library.

Many of you are not familiar with the library; I have never been in it until this morning, and I certainly was very agreeably surprised by what I saw there. I think that we are not using the library to the extent to which we ought to use it; it is certainly there for us and we can use it to the utmost; I believe that we do not realize what it contains, and for that reason we have not taken advantage of the benefits to be derived from it. We have a Librarian who is always willing to give assistance to those who are in the library looking for information, and who is also willing to look up references for those who write for the same. It is quite impossible to furnish extended extracts without remuneration, but the references may be had at any time.

The next order of business is the reading of Mr. Peck's paper on "The Adoption of a Standard Knuckle."

THE ADOPTION OF A STANDARD KNUCKLE.

BY MR. PETER H. PECK.

I will give the Club facts and figures, gathered by close observation during the past seven years in heavy interchange of cars, to show why a standard knuckle should be adopted by the M. C. B. Association. If it were not for the interchange of cars by railroads, Inter-State Commerce Commissions and M. C. B. Rules or Standards would not be necessary. The more cars interchanged the more standards are required, in order that the cost of repairs may be kept at a minimum, and switching and delay to traffic avoided. If the railroads handled only their own cars, standards common to several roads would not be necessary any more than for street cars, wagons or any other class of vehicle. I recollect my first days of railroading—on a road west of the Mississippi river; we had no connection with any other road. Freight was ferried across the river or arrived in steamboats and was transferred to our own cars. The first road with which a connection was effected was the B. & M. at Ottumwa, Iowa, after which time we hauled some foreign cars but for a short distance only. Cars varied in height so much that every locomotive and way car was furnished with three-link coupler in order that our trains could be coupled up. Since that time railroads have extended their lines into almost every town of note, bridged all of our large rivers and connected their tracks at terminals in order that an interchange of cars might be possible. As the volume of interchange increased, new difficulties and dangers arose, viz: Competition, faster time, larger locomotives and cars, and long hauls without breaking bulk. The M. C. B. Association was organized to devise means for overcoming these difficulties and dangers and the annoyances occasioned thereby, and to-day all the leading roads and private car lines are members of the Association; representing an aggregate of over one million cars. Rules governing the interchange were framed and standards adopted, and the adoption by the Association was followed by legislation on the part of both the state and national government to compel the use of the standards.

We have standards for many parts of trucks, and standard drawbars, but the latter ends at the contour lines, leaving the most essential feature, the knuckle, not standard. The knuckle receives the shock first and is, therefore, most likely to be injured, and for this reason, if for no other, it should be interchangeable. Delays of several hours are frequently caused by having to set a car on the repair track to change the bar, because there may be no knuckle at hand which will fit the coupler head. With the link and pin bar such delays would not occur.

During the last few months I have endeavored to secure the names of the different knuckles in use at the present time and the numbers of different de-

signs furnished by each coupler company. The result was much of a surprise to me; the number is still on the increase, as can readily be seen by referring to the list of patents issued each month. The following statement represents the result of my efforts in the direction referred to:

KINDS OF M. C. B. COUPLERS AND KNUCKLES IN USE.

WEIGHT OF KNUCKLE.	NAME OF COUPLER.	NUMBER OF KNUCKLES.	WEIGHT OF KNUCKLE.	NAME OF COUPLER.	NUMBER OF KNUCKLES.
46 lbs.....	American...	2	50 lbs....	Little Dela-	1
	Ajax.....	1		ware.....	2
49 ".....	Barfield.....	1	49 ".....	Mo. Pacific..	1
	Barnes.....	1	37 ".....	Mather.....	1
	Brown.....	1	48 ".....	Murphy.....	1
54 ".....	Burns.....	1		Marks.....	1
46 ".....	Buckeye.....	3	53 ".....	New York...	1
	Cowell.....	1	43 ".....	National....	1
48 ".....	Columbia....	1		Price.....	1
51 ".....	Chicago.....	2	38 ".....	Pooley.....	1
35 ".....	California...	1	49 ".....	Perfected...	1
40 ".....	Champion...	1		Paragon.....	1
	Deetz.....	1	39 ".....	Peerless.....	1
64 ".....	Dowling.....	2		Pacific.....	1
57 ".....	".....			Rickison....	1
60 ".....	Drexel.....	2	55 ".....	Standard....	1
45 ".....	Detroit.....	1	49 1/2 "...	Solid.....	1
43 ".....	Diamond....	1		Shomaker...	1
52 ".....	Excelsior...	1		Saams.....	1
	Edwards....	1		Springer....	1
36 ".....	Empire.....	1		Simplex.....	1
42 ".....	Eureka.....	1	54 ".....	St. Louis...	2
51 ".....	Erie.....	1	47 ".....	Smith.....	1
41 ".....	Elliott.....	1	66 ".....	Standard	
	Foster.....	1		Improved...	1
49 ".....	Forsyth....	1	53 ".....	Smillie.....	2
	Fox.....	1	51 ".....	S. H. & H...	1
38 ".....	Gould.....	1	51 ".....	Safety.....	1
38 ".....	Gallager....	1	50 ".....	Talbot.....	1
	Gifford.....	1	50 ".....	Trojan.....	1
	Gelston....	1	53 ".....	Tower.....	2
51 ".....	Hinson.....	2	50 ".....	Thurmond...	2
41 ".....	".....		46 ".....	Taylor.....	1
38 ".....	Hien.....	2		Timms.....	1
	Imperial....	1		Union.....	1
40 ".....	Interstate...	1	50 ".....	Vandorsen..	1
37 ".....	Janney.....	1	34 ".....	Williams....	3
37 ".....	Johnson...	1	40 ".....	".....	
	Kling.....	1	45 ".....	".....	
	Laburt.....	1		Walker.....	1
61 ".....	Ludlow.....	1	50 ".....	Washburn..	1
50 ".....	Lone Star...	1			

A total of 77 bars and 93 knuckles; nine bars having two, and two bars having three knuckles each, and in only two instances, viz, the Tower and the Chi-

cago, will the knuckles interchange with each other. * The average weight of the 56 knuckles, the weight of which is known, is 48 pounds, the heaviest being the Standard, 66 pounds; the lightest the Williams, 34 pounds.

In order to have, in way cars or at interchange points, knuckles (one of each kind) averaging 48 pounds it would require 4,464 pounds, which, at 3½c. per pound, would cost \$156.24. To furnish one knuckle of each of the above kinds, at sixteen different points and for twenty way cars, it would require 160,704 pounds, representing a value of \$5,624.64.

I find, from the records kept in my office for the past six and one-half years, that as the number of M. C. B. bars handled increased, the percentage of broken bars and of broken knuckles decreased, as shown by the following table:

Year.	Per Cent. M. C. B. Bars.	No. Cars. to 1 Bar Broken.	No. Cars. to Knuckles Broken.
1892	8 per cent.	377	2,476
1893	15 per cent.	385	1,684
1894	20 per cent.	424	1,609
1895	28 per cent.	620	1,663
1896	42 per cent.	996	2,345
1897	48 per cent.	1,240	2,573
1898	59 per cent.	1,872	3,047

A large proportion of the breakage of knuckles occurs when an M. C. B. coupler is coupled with a link and pin bar, such breakages being most likely to occur in heavy trains. In some cases the coupling is made by the pin being placed through only the top hole of the knuckle and into the link; this either breaks off the top lug or breaks out the pin hole; in other cases the knuckles may be broken when two cars strike together and both knuckles are closed. Very few M. C. B. bars are broken when two of these bars are coupled together. Included in our own equipment we have 88 cars and 22 locomotives equipped with M. C. B. couplers; 32 cars equipped last year and the locomotives equipped within the last eight months. As yet we have had but one knuckle broken (that on a car) and that was caused by an accident. One of the engines equipped in this manner is double crewed most of the time for service both night and day. This serves to illustrate the fact that the proportion of breakage to M. C. B. couplers on switching roads is much less than many believe to be the case.

I do not find, in actual practice, the trouble anticipated by Mr. P. Leeds, in his paper before the Central Association of Railroad Officers, as published in the *Railro d Gazette* August 12, 1898, viz: Flange wear, or crowding the flanges against the rail, or that the bar is not strong enough for our modern 80,000 and 90,000-pound capacity cars. We handle hundreds of these cars and the number of breakages of couplers is no greater than with other cars. We do find, however, that when these heavy cars strike very hard the load shifts, in some instances forcing the end out of the car, but not breaking the bar. I have seen cases of rear end collisions and trains breaking in two, and have found that in such accidents the damage to M. C. B. bars was not one-fourth as great as that to link and pin bars. Cars are not as liable to telescope when equipped with M. C. B. couplers as when equipped with link and pin drawbars.

In regard to the handling of passenger equipment, we have five roads for whom we do the switching at Dearborn station, four of which use the M. C. B. bars, the fifth the Miller hook bar. It is possible to couple the M. C. B. couplers on short curves where the same is impossible with the Miller hooks. We have two engines equipped with the M. C. B. couplers in this service and we are able to couple the engine to M. C. B. bars at points where it is impossible to couple the Miller, with link and pin.

Finally, the trucks, draft rigging, drawbar stops, uncoupling levers and knuckles should be standard and interchangeable. The knuckle, most important of all, should receive immediate attention by the M. C. B. Association, and either the patent rights of a knuckle should be purchased by the Association, or six or seven of the best knuckles at present on the market should be adopted as standard; there are, at least, six or seven which are first-class. If something like this is not done before the law goes into effect we will soon be in a worse sea of trouble in interchanging cars than we were in with the link and pin. A cord or hollow knuckle should not be considered; such knuckles are of no value whatever. It is only fourteen months to the time the law takes effect, and something along the lines indicated in the foregoing should be done without delay.

PRESIDENT SCHROYER: There are two communications on this subject which the Secretary will read.

The Secretary then read the following communications from Mr. Ira C. Hubbell, purchasing agent, Port Arthur Route, and Mr. Gustav Giroux, for several years coupler inspector of C., B. & Q. R.R.:

MR. IRA C. HUBBELL (Port Arthur Route): I have before me an advance copy of a paper to be read before the October meeting of our Club by Mr. Peter H. Peck, suggesting the advisability of adopting a standard knuckle for the M. C. B. coupler. I question whether or not there is any railroad official, in any way brought in contact with the M. C. B. coupler question, who is not keenly alive to the importance of accomplishing conditions which will be decidedly more favorable to the railroad interests than at present exist. I have entertained the opinion that were it not for the large number of M. C. B. couplers in use at the present time, this style of coupler would not have been so generally used had its adoption come more gradually; however, we now have it with us to such an extent that, probably, it is here to stay, and, therefore, as a former president of the United States has said: "It is not a theory, but a condition that confronts us." This being the case, the railroads in their own interests, must come to a line of action which will tend to very materially decrease the present expense which attaches to the M. C. B. coupler and such conditions

developed as will facilitate car repairs, as well as produce a net economy.

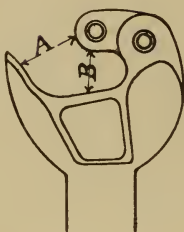
The suggestion with regard to a standard knuckle which shall be interchangeable is a decided move in the right direction, and I shall be glad to support the movement, not only in such of the railway clubs as I may be a member, but also as the representative member of these lines in the M. C. B. Association. I emphatically hope that the Western Railway Club will voice itself unanimously in favor of a standard knuckle, as well as to take the initial move towards a greater economy, which will follow a majority action of the railroads, and which shall demand a reasonable, uniform price to all lines on all M. C. B. couplers. The policy of making "fish of one and flesh of another" road should be discountenanced by every railroad organization. Most of the railroad officials, who are brought directly in contact with the various lines of materials which railroads use, realize the fact that in our purchases we constantly meet a combined front from "the other side of the fence," and it does not seem to me unreasonable that the railroads should take unanimous action in their own interests. Officially or personally, I have no objections to manufacturers making a stand for as long a price as they can get on their product; at the same time, I am entirely convinced that an application of the Golden Rule in business, as well as along other lines, is the best policy. There is a line of equity in all matters, which if followed, wrongs no one; we should find that line and follow it.

MR. GUSTAV GIROUX (C., B. & Q. R. R.): Mr. Peck has brought up a question which certainly merits the attention of all who are interested in couplers, and principally railroad men who have the direct care of the same. The M. C. B. coupler has been a source of great expense to railroads, not only in the first cost of equipping cars but also in the cost of maintaining them in service, yet it seems that when it comes to the question of repair or maintenance very little attention has been paid to the cost; perhaps because it is an M. C. B. coupler. Men at repair points have been accustomed to the old link and pin drawbar which needed no attention unless it broke, and when broken a new bar was applied. In most cases the bar had the pattern number cast on it and this helped in getting the right bar to replace the broken one; this is not the case with the M. C. B. coupler and, on account of its numerous parts and the absence of identifica-

tion marks, when a certain part breaks and must be replaced the trouble commences, as Mr. Peck has said, because it is not known what kind of a piece is needed. I think railroad companies ought to be more particular than they have been, when buying couplers, and insist that the couplers be put together in a workmanlike manner and that all parts be made uniform; then the railroads should see that, when cars are inspected, the same attention is given to the coupler as to the body of the car, to truck or to air brake.

Not long ago I was talking to a foreman of a large freight repair shop about the M. C. B. coupler and he was telling me about some defects he had found in a certain coupler, which he considered very serious; at last he expressed himself like this: "This coupler question never received enough attention; after an M. C. B. coupler is put on a car no attention is given it; in case a certain part breaks that part is made good, or, if not, the remainder of the coupler is set aside and a new one put in and nothing said about it." I really think if all such experiences were made known to the superintendents of motive power or to the master mechanics the troubles to which Mr. Peck alludes would have been done away with long before this. It might seem unreasonable to say this, but there are some people who think that anything is good enough for a coupler and all that is needed is to get the different parts together, regardless of how they fit, so long as the couplers can be coupled together and be used to pull cars. It is true that an M. C. B. coupler is not a very fine piece of mechanism, no more so than is a common hinge, yet a hinge can be put up in such a way that it will work very unsatisfactorily and give trouble each time the object, upon which the hinge is placed, is operated. Again, the life of that hinge will depend greatly upon the fit and the attention given it when it is put together; the same is true of the M. C. B. coupler. Up to now, the life of each part ends when the part breaks or when the knuckle is worn out.

A point that ought to receive some attention soon, is the amount of play that can be allowed around the contour line before the coupler becomes unsafe. There is an M. C. B. gauge that gives a minimum and maximum limit to this play, and the requirements are demanded by a few roads when buying new couplers; but is there no limit to this play after the coupler is put in service?



Is a coupler that measures $5\frac{3}{8}$ inches at A, and $4\frac{3}{8}$ inches at B, safe to run? These figures were taken when the knuckle was locked and knuckle pulled out by hand, so as to take out the slack. It would be very interesting, I think, to take these measurements when couplers uncouple while in service and while both knuckles are closed. There are hundred of couplers put into service which do not pass, or meet, the requirements of the M. C. B. gauge, and it does not surprise me, knowing in what way couplers are fitted together, that we can find in service couplers measuring as above.

It will pay to get couplers fitted together in a better manner and with as little lost motion as possible, because we all know that a coupler wears loose too soon. Require that the contact parts of the coupler be smooth and clean, free from sand grit or scale and the coupler will work easier. I think it would be much better for all roads to request the manufacturers not to paint couplers, but to put the cost of painting into producing smoother and cleaner castings and fitting the same together with more care; this would enable us to see who are turning out the best castings. I was amused on one occasion to hear it said that the paint applied acted as a lubricant between the face of bar and the knuckle, and the couplers would therefore couple easier. This, I think, is as good as if a car wheel manufacturer would paint, or oil, the tread of wheels and state that he did so to make the wheels run more smoothly. Paint on couplers has hidden large numbers of defects; this is really all that it is good for.

I hope that a standard diameter and length of pivot pin will be adopted; we now have pins $1\frac{1}{4}$, $1\frac{3}{8}$, and $1\frac{1}{2}$ in. in diameter and find couplers made for $1\frac{1}{2}$ -inch pivot pin repaired with pins $1\frac{3}{8}$ or $1\frac{1}{4}$ -in. in diameter. Again, if a cotter or split key is put through the lower end of the pivot pin, I think we would not hear of so many pivot pins working out of place. I think that a man making repairs on a truck and

finding it necessary to remove and then replace a McCord or Fletcher lid from an oil box, would not just slip the bolt or pin in place without making it fast so it would not fall out; is the same care given when removing and replacing a knuckle pivot pin? I have seen a round coupling pin used for a pivot pin; also a knuckle of a certain coupler put in a bar of a different make; I have known repairs similar to the latter to cause breaks in the train three times in a distance of thirty-eight miles; at last the crew used a link and pin and set the car out at the first inspection point. The inspector inspected the car or coupler, and decided he would try another knuckle, which happened to be the right kind; he did not know why the one he took out did not work—it was a new knuckle also. The car went out again and no further trouble was heard from it. I know that no report of it was ever made, so that those who ought to have known of the difficulty could not take action to prevent such mistakes in the future.

I hope that the M. C. B. Association will get out very soon a standard specification, specifying not only what kind of a test couplers shall stand, but also specifying the length of guard arm, amount of play around contour line (not only for new couplers but also for couplers in service), diameter and length of pivot pin and diameter of hole, thickness of knuckle through pivot pin hole, and distance between lugs of bar, and that all parts shall be plainly marked at a specified place in such a manner as to enable ordering parts for repair. It would not be necessary, then, to make a photograph of what is wanted, as is now sometimes the case. I think that if the above is carried out, not by a few roads, but by all roads, the many troubles we now have will be reduced greatly and the number of couplers of different kinds or styles will be reduced also.

Another good feature of Mr. Peck's suggestion is, that if the number of styles of knuckles is reduced, there will be less difficulty in keeping the unlocking rigging in shape and a better standard of uniformity will be possible.

Let us bear in mind that we do not have a straight bar of cast iron, but a coupler which is a piece of mechanism by itself and which needs attention the same as do the trucks or the air brakes; if this is done it will very easily and quickly bring out the best couplers and will reduce the number to a few. We must not hold the manufacturers or the coupler companies responsible for troubles arising

from worn-out parts, for I have never heard of a coupler guaranteed not to wear out. Railroads must look after the wearing, and discard knuckles and couplers which are worn too much, and if that is done the other party will certainly meet us half way.

PRESIDENT SCHROYER: The paper is open for discussion. I presume you have all observed that in this paper Mr. Peck indicates he would like to see a standard knuckle adopted. Have any of you considered the question as to what is involved in the adoption of a standard knuckle? Have any of you a solution of the problem of adopting a standard knuckle without adopting a standard drawbar and standard locking apparatus with it? If this is accomplished, we will have one drawbar, one locking-block and one knuckle, and a continued use of the contour lines which we have at present.

MR. A. M. WAITT (L. S. & M. S. Ry.): I think no one will question the desirability of having a standard knuckle for couplers, but I think many will question the probability that we shall ever enjoy such good fortune. Mr. Peck has shown in the table given in his paper, the great variety of knuckles, and, excepting two, none are interchangeable with those of other makes. On this account it seems to me that we are a long distance from anything like uniformity. I think that it would not be practicable to attempt voting into existence anything in the way of a standard coupler or a standard knuckle. We have a bad condition of things, and the only way to get out of it is by the same way that must be practiced in moral affairs. If the general moral tone of a community or a class of people is on a low plane, it is impossible to legislate the community into perfection. The improvement must be accomplished by slowly educating public opinion to the higher plane. It seems to me that to approach uniformity in the M. C. B. couplers, or in the knuckles, can be accomplished only gradually and by educating people to appreciate what is the best. I believe we can, however, go a great way toward eliminating the poorer class of couplers and knuckles, either by bringing about the survival of the fittest, or in some other way reduce to a few the number of couplers in the market. That can only be done, I believe, by adopting a specification of some kind, as suggested in Mr. Giroux's discussion; and I believe that specifications carefully prepared by an impartial committee, by the Master Car Builders' Association, or, perhaps, by preliminary work in the clubs, might accomplish much by driving

out a great many of the undesirable couplers that are causing us expense and bother in carrying material in stock; and by forcing the better class of couplers to be made in accordance with the demands of a higher standard of efficiency and of quality. I believe that before the subject of M. C. B. couplers is dropped this Club, if no other organization, should take the initiative and compile practical specifications for couplers that will assure us, if they are fulfilled, of getting the best out of the forty or fifty couplers which Mr. Peck has enumerated in his paper.

MR. PETER H. PECK (C. & W. I. R. R.): The solution that Mr. Waitt offers is one I have had in view, namely, accepting five or six couplers as standard. In the present state of affairs, roads that are using good couplers pay for the bad couplers. Mr. Waitt might, as he thinks, be using the best coupler, and Mr. Mackenzie might be using another best coupler; but if their cars get on a road which has a cheap coupler that was removed on account of a broken knuckle, the inspector will get rid of the bad coupler by replacing it with a good one, and the road using the good coupler has to pay for the bad one.

MR. JOHN MACKENZIE (N. Y. C. & St. L.): The remark of Mr. Waitt suggested an idea to me; that the Club might suggest to the Interstate Commerce Commission to have the Patent office refuse to accept applications for patents on M. C. B. couplers for the next five years, and give us an opportunity to work out all that we have on hand now. Another way of bringing about the survival of the fittest is in the hands of the railroads. I think the larger roads are adopting what we may call a fairly good coupler. When an undesirable coupler is broken, a second-hand good coupler may be used in replacement and the undesirable ones will be driven out gradually, and it will be possible to carry less stock for repair. I think the first suggestion relating to the Patent office is a good one.

MR. CLEMENT F. STREET (*Railway and Engineering Review*): It seems to me that this paper by Mr. Peck brings out very forcibly the importance of specifications and tests for M. C. B. couplers. A few years ago a number of public tests were made by committees from this Club and from the Master Car Builders Association, the first test of any importance being conducted by a committee appointed by this Club. I remember very distinctly that this test brought out

weak points in some of the couplers submitted and immediately after the tests several manufacturers started their pattern makers and engineers to work making changes which were beneficial not only to themselves, but also to the railroad companies. These tests have undoubtedly aided in driving from the market a number of undesirable couplers, and it would seem to me that the revival of this practice would eliminate some of the poor couplers which are being used.

Our President has said that the adoption of a standard knuckle would involve the adoption of a uniform bar and locking arrangement, but I understand that one of the roads is already using a uniform knuckle for all M. C. B. couplers. This is, however, rather a makeshift for use on the road in case of a break-in-two and could hardly be accepted in interchange. This knuckle is constructed with a slot in the tail which passes over the back wall of the coupler behind the pin. The knuckle is, of course, rigid and will not open and close, and when it is removed the pin must be pulled out. It can be coupled with any other coupler which is in good repair, but of course two of them could not be coupled together. This is, as before stated, a makeshift, but is an exceedingly convenient arrangement for use on the road. One or two of these knuckles can be carried in the caboose, and in case of a knuckle breaking on the road it saves considerable delay and avoids the use of chains.

MR. F. A. DELANO (C., B. & Q. R. R.); I agree with the various gentlemen who have spoken here, and especially with what Mr. Waitt has said, with regard to the impracticability of adopting even five or six standard knuckles. It seems to me, as Mr. Waitt has put it so well, that the only way we can improve the situation is by elevating the tone of public opinion on this question. I think it is something on which quite evidently the Interstate Commerce Commission needs instruction. They are flattering themselves that they are compelling the use of an automatic coupler; and yet, if you will talk to trainmen and switchmen, you will find that the latter do not regard the M. C. B. coupler as an automatic coupler. They will tell you that they have to ride the cars, both to couple and uncouple them, and to hang on by their eye-teeth to hold up the pin and to insure the cars will uncouple while in motion. Surely, that is not the kind of coupler that the Interstate Commerce Commission think that they are compelling the roads to put on. Now, as a way of

educating public opinion and railway men and congressmen on this question, why would it not be a good idea for us to send our Proceedings, with this paper and these criticisms on it, to the various railway clubs and ask the officers of those railway clubs to set a time for a meeting at which the whole question can be discussed? I would also suggest the appointment of a committee by us, to look into the whole question, not to confine it to the question of the "knuckle," but also to the other parts of the coupler, and to some of the points brought out by Mr. Giroux; for example, that these M. C. B. couplers are being put on cars without complying, in the first place, with the M. C. B. regulations.

It seems to me that the suggestion of Mr. Mackenzie is a good one, that roads, instead of trying to replace a peculiar or an odd coupler that has been broken in service, with one of a similar kind, should be allowed (and it would be better for all concerned) to replace those couplers with a coupler of recognized merit. However, all these are suggestions which the committee could consider.

I recently saw two cars, just out of the shop, fitted with deadwoods, the couplers on which the switchmen could not couple. They jammed the cars together ten or fifteen times, but the cars could not be coupled together, and it developed that there was so much slack in the spring that the couplers were pushed in beyond the point where the deadwoods kept the cars apart. This illustrates the points made by Mr. Giroux that many cars are fitted up improperly, and that the M. C. B. coupler is a piece of mechanism that requires more attention than has been given to it. It occurs to me that if the suggestion of referring this to various railway clubs meets with the approval of the members, it will be discussed by all the railway clubs in the country, and some of them, at least, will appoint committees to make suggestions, and in that way we will get a thorough agitation of the question; and even if those committees were not ready to suggest to the M. C. B. Association to recommend a standard drawbar, they might be able to reduce the number of 77 couplers, which Mr. Peck has enumerated, to, say, 27, and in any case it would have the effect of indicating some of the very serious faults in the so-called automatic coupler.

MR. H. R. CURTIS (Latrobe Steel & Coupler Co.): I think that a great deal of the fault found today with automatic coupler equipment is not due to the non-education of the Interstate Commerce

Commission, but to the fact that a great many railroads have followed the practice of buying and applying the cheapest coupler on the market. A cheap coupler is applied, and the men who have charge of the operating department do not know how the couplers work. Education is not for the Interstate Commerce Commission, but for the railroad men themselves, to know how a cheap coupler operates after they buy it. I think the same is true of most of the automatic coupler equipment of today; if the railroads of the country had adopted a standard test, and followed that test, they would not have had one-third of the many types of automatic couplers that are now in service; a great many of these couplers could not have been sold if the M. C. B. (so-called) test or any sort of guarantee had been required.

A reputable coupler maker will not make a coupler the mechanical construction of which is bad, and if the mechanism and material are good you will not have anything like the experiences you have had with automatic couplers. Good mechanism and good material, if insisted upon, will drive out poor couplers faster than anything of which I know.

Mr. Mackenzie suggested that when a part of a coupler breaks, "take away the bad coupler and put in a good one." I do not know how that can be done under the present M. C. B. rules. The price fixed for an automatic steel knuckle is $3\frac{1}{2}$ c. per lb.; the credit the railroad must give for scrap is $\frac{3}{4}$ c. per lb., leaving $2\frac{3}{4}$ c. net per lb. for a *good steel casting*. Possibly they can be made for that, but I think not.

MR. GEO. S. PAYSON (Western Railway Association): I think there is little that I can add. I think really it is a question of price. I have had at my office, a number of times, meetings of various representatives of coupler companies; they considered the adoption of a standard coupler, but each time the deliberations came to naught because somebody would undersell the price by \$2.00 a bar, and the deliberations would end immediately. If six or seven of the best couplers are chosen, somebody will offer couplers at, say, \$2.00 apiece cheaper than the agreed price. It has been claimed that these cheaper couplers are not fit to use, but some roads continue to use them.

Mr. Peck says that the knuckle, at least, is not in any sense standard to the contour lines adopted. I believe that the January

patent of 1889 included that part of the knuckle just outside of the drawbar. It included the head of the knuckle, but not the tail. I do not see how you can adopt any knuckle that would work in all the different couplers. Mr. Peck suggests the purchase of patent rights. I know a little about the patents, and there is not a patent on any knuckle that would interchange with all couplers. So far as my best information goes, there are only four knuckles that are covered by patents; these will not interchange with other knuckles. I question whether these patents are good, anyway. I should think if you adopt a standard knuckle, which I do not think is possible without a standard coupler, you would have to take a coupler the patent on which had expired, or design a new knuckle and patent it for the M. C. B. Association. We have no knuckle the patent on which I think is worth purchasing. I think the price will defeat the adoption of a standard knuckle or coupler, unless you can secure an agreement on the part of the roads that they will not buy at less than a certain price. I have considered this thing a great many times within the last five years, and the price has always knocked out anything I could do.

PRESIDENT SCHROYER: The question of quality has been referred to. I think it is not the question of quality that is giving us so much trouble today, but rather the question of variety and the quantities of the different kinds of knuckles that are in use. The main object to be attained, as I understand this discussion, is a reduction in the number of kinds that are in use. I think none of us are satisfied with the automatic coupler. The Chicago & North-Western has figures which show very conclusively that it is costing very much less to maintain cars equipped with the automatic coupler than it ever did cars equipped with the link and pin and the cast-iron drawbar. In the maintenance of the old link and pin bar, the question of links and pins was ignored by the car department men, because they had very little to do with such parts. The requisition for links and pins was made by the superintendent of each division, and the men in the mechanical department knew nothing about the number used. After we began to keep a record of the cost we found that the big expense of keeping the department was the cost of links and pins, and not the cost of the bars. We have our entire equipment equipped with the automatic coupler, and the cost of maintaining it, in which is included the cost of couplers

which we put on the foreign cars, is so much less than the cost of the links and pins that we are entirely satisfied in so far as the cost of maintenance is concerned. The main question is the avoiding of difficulties in interchange as the result of breaking these various kinds of couplers; and I would be very glad, indeed, if some one could devise a knuckle that would be interchangeable with the different makes of couplers, but I do not see how it can be accomplished.

Mr. Delano spoke about a committee, the principal work of which should be to investigate the couplers and recommend certain ones for general use. Have you any motion to make requiring the appointment of such a committee?

MR. DELANO: I move you, Sir, that in the first place the minutes of our meeting, with the paper by Mr. Peck and the discussion on it, be sent to the railway clubs of the country, with a request to the officers of those clubs that the whole subject be taken up and discussed by them; and that a committee of five from our membership be appointed by the Chair to consider the subject in its broad aspect, not confining themselves to the question of knuckles, but considering the whole subject, and be prepared to report at some future meeting of the Club what action they would recommend. I do not want to tie the members of that committee in any way. They may find, after looking into the subject, that absolutely nothing can be accomplished. (Seconded.)

PRESIDENT SCHROYER: You have heard the motion made by Mr. Delano, that a committee of five be appointed by the Chair to investigate this subject.

MR. DELANO: My idea was that they should report back to this Club.

PRESIDENT SCHROYER: Report back to this Club the results of their investigations. Are you ready for the question? All in favor of Mr. Delano's motion give their assent by saying aye. Opposed no; it is carried.

I will appoint on that committee Mr. Delano as chairman, Mr. Peck, Mr. Barr, Mr. Mackenzie and Mr. Fildes.

The next order of business is the topical discussion: "What is the Best Disposition to be Made of the Exhaust from the Air Pump?" It was expected that Mr. Marshall, of the Chicago and North-Western, would open the discussion, but he is unexpectedly absent.

The Secretary will, therefore, outline the subject as it is desired to have it considered in the discussion.

SECRETARY WHYTE: The disposition generally made of the exhaust from the air pump, is to conduct it to the front end of the boiler and direct it up the stack, but the objection to this disposition of the exhaust is that the time when the pump is working the hardest and having the greatest effect on the fire is just the time when the fire should be agitated the least. It has been suggested that it might be best to conduct the exhaust to the ash pan, but some claim that this causes difficulty in the winter, the water accumulating in the pan and freezing. A few have changed the direction of the discharge in the front end, and instead of directing it up the stack have directed it against the sheet or the door. It would be interesting to know whether the exhaust from the pump, directed across the current from the tubes, would affect the draft as produced by the exhaust from the locomotive cylinders, and if any one has had any experience with such an arrangement, or has made any experiments in that direction, the Club would like to know the results. Again, the exhaust has been conducted to beneath the cylinder saddle, and some roads are now following the practice of conducting the exhaust from the air pump to the cylinder saddle, sometimes delivering it inside the saddle to the exhaust passage, and sometimes outside the saddle, directed toward the ground. If it is conducted inside of the saddle to the exhaust passage, the water and oil which is collected while the locomotive is not using steam in the cylinders is thrown out the first time there is a heavy exhaust from the cylinders, and of course this is objectionable.

MR. PECK: I have conducted the exhaust from the air pump direct to the fire box, through a hole that was used for a smoke burner. I have also conducted it to the ash pan, and that was not satisfactory. I direct it now up the stack, because I think that is the proper place for all exhaust steam. If the exhaust from the pump affects the fuel consumption unfavorably, I remedy the evil effects by enlarging the holes through which the steam escapes.

PROF. W. F. M. GOSS (Purdue University): The effect of the exhaust on the fire can easily be reduced by running the pipe to the top of the stack. I know that some roads are doing this. But it is not worth while to ask whether the action of the pump exhaust on the fire really is objectionable? It is true that it comes into play

just at a time when there is no demand for steam, and that it may operate to increase losses through the safety valve. But it need not necessarily do so. Again, is it not a fact that engines very frequently run into stations with the blower on? If so, it is evidence that the pump exhaust does not always give draft enough to suit the fireman. The fireman must often do work on his fire after the throttle has been closed and if he is not aided in this by the pump exhaust he will use the blower. I am not prepared to say that the air-pump exhaust in the front end is necessary as a means of producing draft, but there are times when it is useful for that purpose. The question, therefore, presents two sides.

MR. PECK: The Wabash railroad formerly conducted the exhaust back to the center of the top of the cab. The Monon has been doing this on some locomotives that run into the city. I notice that both the above roads are doing away with this practice, but do not know for what reason.

I have noticed, particularly when running against a head wind, that the front end of the baggage or mail car was covered with water and oil from the exhaust of the air pump when the exhaust escaped just above the cab.

MR. J. H. SETCHEL (Pittsburgh Locomotive Works): What is the objection to putting the exhaust in the tank to heat the water? I expected to hear somebody suggest that the first thing, and I have begun to think maybe it would bite somebody or something. I do not know what there is about it. It seems to me that there is a great deal of surplus heat in the exhaust from the air pump, as well as a great deal of force, that creates an undue draft on the engine, as has been suggested by the Secretary, just at the time it is not wanted. The pump is always working hardest when the air is being used, and the fire need not be so fierce, but instead steam is being wasted through the safety valve. It seems to me that the thing to do is to conduct the exhaust to the tank, and so heat the feed-water. The same has been done with the steam escaping from the safety valves, but the objection to the latter has been that the arrangement is very expensive. I have seen a device, and I presume there are others here who have seen it also, that has been gotten up by Mr. Barnes, of the Wabash, which directs the exhaust to the tank simply by moving a bell-crank at the hand of the engineer. The exhaust from the pump can be directed to the stack or into the

water in the tank without producing any effect in the working of the air pump. The arrangement is very simple. It seems to me that the exhaust can always be put into the tank until the temperature of the water is raised as high as it is desirable to have it. The exhaust can be changed from the stack to the tank when the locomotive is standing at stations where it is objectionable to have it directed up the stack on account of the noise. It seems to me that this is the most reasonable arrangement I have seen or heard suggested lately for the disposition of the exhaust from the air pump. It is one that will result in the saving of fuel at the rate of 1 per cent. for every 11 degrees increase in the temperature of the feed-water.

MR. MACKENZIE: I understand that the objection to introducing the exhaust steam into the tank is that there is considerable oil carried over, and it is feared the oil may cause trouble when it reaches the boiler. I believe that in connection with Mr. Barnes' patent there is a device used for extracting the oil from the steam as it is passing back. If the separation can be thoroughly made, I do not understand why the exhaust steam cannot be put right into the tank.

MR. SETCHEL: There is a trap used with Mr. Barnes' device which catches the oil, and that in turn is opened right into the cylinder cap. Nothing but the pure exhaust, free of oil, goes into the water in the tank.

MR. WHYTE: There is one strong objection to putting the exhaust from the air pump into the tank, and that objection concerns the engineer to such an extent that he will be sure to protect himself against it. If the water gets too hot to be handled by the injectors and an engine failure results, he will be very careful not to allow the same thing to happen again; and in his anxiety to protect himself against such an accident, he will use all precaution possible and not heat the water.

MR. SETCHEL: If the engineer has something to indicate the temperature, he can regulate the temperature of the feed-water by putting the exhaust into the tank or diverting it to the stack. It is just as important to him not to allow the steam to escape from the safety valve, and he will not put in coal unless it is necessary. It seems to me that one of the greatest safeguards against a waste of fuel that can be put on an engine is one similar to the one described.

MR. E. M. HERR (Westinghouse Air Brake Co.): I would like to relate some experiences which we had on the Northern Pacific road, and can testify that the exhaust can be used to heat the feed-water with entire success under certain conditions. The last eighteen engines that were built for the Northern Pacific under my jurisdiction had pipes leading from the exhaust side of the air pump through the tank, and in order to get rid of any possibility of oil giving trouble in the tank, the pipe did not deliver the steam into the tank; the water of condensation dropped upon the roadbed after passing through the coil of pipe in the tank. The arrangement of this pipe was as follows: It was brought up on the right-hand side, right next to the tank valve and vertically to the top of the inside of the tank. From this point it extended toward the back and downward in a gradual slope, and zigzag across the tank the width of one water leg until it finally passed through the tank near the back. As the water in the tank got lower, the heating surface exposed to it was continually reduced, and the amount of heat going into the water was correspondingly less; consequently, there was less liability that the water be heated to too high temperature. When the tank was full, of course the water came in contact with more heating surface and more heat was absorbed by the water. If the engineer ever did get caught with water so hot he could not work the injector, it always occurred with the right-hand injector first, because the pipe went into the right side entering near the feed valve opening. In such a case he can always readily start the left-hand injector, because in the left leg of the tank there is no heating pipe, and there is a considerable reservoir of cold water which can be used in an emergency and to supply cold water enough to be used by the left injector until the next water station is reached. I was surprised to find that there was very little difficulty of this kind on these passenger engines; there were sixteen of them hauling through passenger trains, doing pretty heavy service, and the engineers ran the exhaust into the tank continuously, very seldom having to divert it on account of the water getting too hot; that happened only in very hot weather. In the fall and spring and of course, throughout the winter, there would be no occasion for them to change the exhaust from the tank. This is a very important factor in saving of fuel, as can be very clearly seen when one considers that, as I believe the authorities estimate, for every 11 degrees rise in the temperature of feed-water, there is a saving of

about 1 per cent. of coal used in the generating of steam. This is a theoretical consideration, but I thought we could notice in the fuel consumption and in the steaming of the engine in cold weather a very undoubted and practical advantage.

MR. DELANO: How much did you raise the temperature of the water, practically?

MR. HERR: In practice the temperature was rarely raised above 90 degrees, and 90 degrees is about the limit at which an ordinary injector will handle water. I did a great deal of experimenting with different makes of injectors to find out which would handle the hottest water. If, as seems to be the case, one can effect a saving of 1 per cent. of coal for each 11 degrees increase in temperature of feed-water by reason of using the exhaust steam, we certainly should get that injector which will handle feed-water at the highest temperature possible, and obtain this economy. By experimenting I found one injector that would handle feed-water at a temperature of 124 degrees.

A MEMBER: What one was it?

MR. HERR: I suppose I ought not to say it, but it is a fact. I placed a large number of those injectors in service, and the engineers had no trouble in handling them with the feed-water at a temperature of 100 degrees and over.

MR. MACKENZIE: I would like to ask Mr. Herr if there was any complaint from the road department on account of the drippings from the engines around the roundhouse tracks? That seems to be a pretty serious matter in the winter, when it is necessary to keep men digging away the ice and snow.

MR. HERR: No, sir; we have had no trouble of that sort. The exhaust from the pump when the locomotive is detached from the train would cause only little difficulty; in any event, the exhaust can be turned into the stack at any time.

MR. ROBERT QUAYLE (C. & N.-W. Ry.): I think it was in 1891 that the experience occurred which I shall relate. There was a water tank the water for which was supplied from a spring, and we found that the engine working on the way freight train in that locality was so very sensitive to steam making that when it got the water from this particular tank it would not make sufficient steam to do the work. The road foreman of engines said to me it was because this spring water was colder than any other water on the

division, and he suggested that they use exhaust steam from the pump, used for pumping the water into the tank, for heating the water in the tank. We did so, and we had no more trouble with that engine when using the heated water from that tank. That led me to suggest that it would be a pretty good thing to turn the exhaust steam of the air pump back into the tank. We did so, and the road foreman thought it was a very good thing, and he thought, inasmuch as we had a pretty good thing, we ought to have some more of it; and we put in a little more pipe and found we had too much of it; the water became too hot for the injectors. I believe that, even without permitting the pipe to run through the tank and letting the water of condensation drip on to the roadbed below, we might, by giving the matter considerable care, get a sufficient quantity of pipe into the tanks to heat the water to the proper temperature, or below 100 degrees, and not encounter any difficulty. By the use of the exhaust steam in this way, I think that there should be some saving in fuel; not very much, perhaps. I think that there would also be a saving in the painting of the tanks. I believe that if the sweat did not cover the tanks the paint would remain in good condition for a longer time. We have quite a number of engines on the North-Western road equipped in this manner, and I have thought that, if we could have a valve that would automatically open and close with the variation in temperature, the direction of the exhaust steam would be changed, as the temperature indicated, either to the atmosphere or into the tank. By this means I believe that we could get rid of the bad effect which the exhaust has when directed through the stack. If we do as Prof. Goss suggested, and conduct it in a pipe to the top of the stack, the noise is likely to scare horses at stations and cause damage for which the legal department will get after us.

SECRETARY WHYTE: Mr. Quayle has suggested that, by heating the water in the tank, the paint on the tank may be preserved. I have seen just the opposite. One road in the east, some time ago, connected the escape from the safety valve with the tank, and the steam that was wasted through the safety valve was conducted back to heat the water in the tank. In several instances the water got so hot as to destroy the paint on the tank. The experience was had with switching locomotives.

MR. QUAYLE: I was speaking within the limits of the working of the injector.

PROF. GOSS: As I understand this method described by Mr. Herr, it may or may not result in the condensation of all of the exhaust from the pumps. Am I right?

MR. HERR: That is correct. When the water in the tank is low, the steam is not all condensed.

PROF. GOSS: It amounts, then, to an exhaust at the back of the tank.

MR. HERR: It does, yes.

MR. E. W. PRATT (C. & N. W. Ry.): I would like to mention one other method of using the exhaust steam to which reference has not been made; that is, in the heating of cars. Such disposition of the steam has been put into practical use by several roads. The Chicago & North-Western has one suburban train of two cars, and running in the Lake Superior district, that during two winters has been heated entirely by exhaust steam from the air pumps. I would like to say further, in reply to the remarks, that oil from the air pump exhaust delivered to the tank is a disturbing element; engine failures due to foaming and bad conditions of feed-water occur generally in districts where the feed-water is bad; but if there may be any excuse for the foaming, such as oil delivered by the exhaust into the tank, the failure is always reported as caused by the oil. On one of the divisions of the North-Western the exhaust from the air pump leading directly into the tank caused all the failures, according to reports, that were chargeable to water foaming in boilers. Before the tanks were so equipped, the failures were attributed to other causes; but after the tanks were so equipped, the arrangement was the excuse for all the trouble. The exhaust was then continued through the tank and allowed to drip on to the road-bed, as Mr. Herr has said was done on the Northern Pacific, and no more trouble was experienced. After a few weeks the pipe was cut inside the tank, the engineers not knowing of it, and the exhaust delivered directly into the tank, but caused no more engine failures. The arrangement has been in use for more than two years, and has caused no inconvenience. I am reminded of the story of the brakeman who dropped the bottom of his lantern into the tank. The lantern contained animal oil, and he had hardly time to get down from the tank to notify the engineer of what had happened, before the

engine had foamed so badly that it could not be run over the road and was towed in.

MR. QUAYLE: I would like to ask Mr. Pratt if he has any figures that would determine if the back pressure on the pump, when discharging back into the two cars, had any effect on the fuel consumption?

MR. PRATT: No, sir, I have not; I should like to get such figures. However, we know that there is a certain amount of steam condensed; the principle is that of a surface condenser wall, and while in condensing it may not form a vacuum, yet, undoubtedly, in the two cars the condition approaches a vacuum. I can say that the Union Pacific made some crude experiments, and considered that a saving in fuel might result. Aside from the exhaust from the pump, they had a pressure reducing valve that automatically opened when the exhaust from the pump failed to give a certain required pressure, and the deficiency was made up from the boiler direct. For instance, it was deemed advisable to have 20-lb. pressure at the engine to heat a certain length of train; if the air pump failed to supply twenty pounds pressure the reducing valve opened and the deficiency was supplied from the boiler direct. If the back pressure on the pump became greater than thirty pounds an overflow valve opened and allowed the steam to escape to the front end. I think that, with the high steam pressure generally carried on locomotives today, there would be no difficulty in supplying the pressure of air required; some difficulty might be experienced with the low pressure boiler.

PRESIDENT SCHROYER: Before we adjourn I wish to say a few words about subjects for papers and subjects for discussion for the Club. Many of you do not appreciate the advantages you may derive from the Club, or, if you appreciate them, you do not take advantage of them. Whenever, in your practice, a question is presented on which you would like to have the opinions of others, write to the Secretary and suggest it for topical discussion, or, if it is of sufficient importance, it may be possible to get some one who is familiar with the subject to prepare a paper on it for the Club. Kindly bear in mind these remarks and correspond with the Secretary in the way suggested.

Adjourned.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED APRIL, 1884.

(INCORPORATED MARCH, 1897.)

NOVEMBER 25, 1898.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 3.

CHICAGO, ILL.

\$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Roadmaster, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER.	JOHN W. CLOUD.
F. W. BRAZIER.	H. G. HETZLER.
PETER H. PECK.	F. W. SARGENT
PROF. WM. F. M. GOSS.	

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio

A regular meeting of the Western Railway Club was called to order at 2 p. m., Tuesday, November 15th, 1898, in the Auditorium Hotel, Chicago, Illinois. The President being absent the Chair was occupied by Mr. F. W. Brazier, First Vice-President.

Following are the names of those who registered:

Amory, E. P.	Gardner, J. W.	Sargent, F. W.
Anderson, Tom.	Goehrs, Wm. H.	Sawyer, Edw. C.
Bischoff, G. A.	Gollmar, Geo. J.	Schacks, Henry
Blanchard, W. A.	Goss, Prof. W. F. M.	Schoenberg, C.
Brazier, F. W.	Hetzler, H. G.	Scott, G. W.
Cardwell, J. R.	Hill, James W.	Shea, R. T.
Church, Townsend V.	Keeler, Sanford.	Showers, G. A.
Church, H. L.	Kuhlman, H. V.	Smith, L. L.
Clark, F. H.	Lane, F. W.	Smith, Frank P.
Clifford, C. J.	Lowell, W. W.	Smith, Julian E.
Cooke, W. J.	Luttrell, J. W.	Smith, R. D.
Cooke, Jas. W.	Mabbs, J. W.	Street, Clement F.
Crosman, Walter D.	Maher, P.	Thurtell, B. W.
Cushing, Geo. W.	Miller, Wm.	Tratman, E. E. Russell
Davies, W. O.	Molleson, Geo. E.	Waitt, A. M.
Deems, J. F.	Morris, A. D.	Wakeman, C. J.
Delano, F. A.	Noble, L. C.	Whitridge, J. C.
Doebler, C. H.	Pennington, B. C.	Whyte, F. M.
Elliott, W. H.	Rennolds, W. C.	Williams, J. C.
Farmer, Geo. W.	Rhodes, G. W.	Wood, G. S.
Forsyth, A.	Rogers, M. J.	Woods, J. L.
Furry, Frank W.	Sanborn, John G.	Woodman, G. A.

THE CHAIRMAN: The minutes of the October meeting have been published in the Proceedings, and if there are no corrections to be made in them they will stand approved. Hearing no objections the minutes are approved as published.

The next order of business is the reading of applications for membership.

The Secretary read the following list of applications for membership, which had been acted upon favorably by the Directors:

- Mr. W. J. Bohan, Electrical Dept., C., M. & St. P. Ry., Chicago, Ill.
- Mr. W. H. Forsyth, President & Treasurer, Forsyth Bros. Co., Chicago, Ill.
- Mr. W. H. Maddocks, Chief Draftsman, Mach'y. Dept., M., K. & T. Ry., Parsons, Kan.
- Mr. John Medway, M. C. B., Swift Refrig. Trans. Co., Chicago, Ill.
- Mr. F. E. Place, Gen'l. Foreman, I. C. Ry., Chicago, Ill.
- Prof. W. H. Vandervoort, Mechanical Engineering Dept., Univ. of Illinois, Urbana, Ill.

THE CHAIRMAN: The next in order is the paper entitled, "The Framing of Cars," prepared by Mr. F. M. Whyte.

THE FRAMING OF CARS.

BY MR. F. M. WHYTE.

The purpose of this paper is to enlarge upon some remarks made by the author at the May, 1898, meeting of the Club, when the question of transmitting through the side bearings a part of the load to be carried from the body bolster to the truck bolster was under discussion. There has been much discussion, verbally and in print, concerning the strength of bolsters, both body and truck, and the necessity of providing stiffer bolsters has been appreciated very generally; but that there has been much difficulty in providing bolsters which shall deliver to and receive from, the center plate the load imposed, and maintain the side bearings free of contact with each other, and at the same time fulfill the several requisites of the commercially successful bolster; viz., of lightness, and of cheapness in first cost and in cost of repairs, is indicated very strongly by the fact that more than a few men in charge of rolling stock have considered whether it is advisable to support a part of the load on the side bearings. If further evidence of the weakness of a majority of the so-called "metal" bolster is required, it is furnished by the large number of friction reducing (not "frictionless") side bearings which have been devised. It is probably unnecessary to present arguments in proof of the opinion that the load should be carried on the center plate independent of any assistance from the side bearings; the general opinion, judging from expressions made at the May, 1898, meeting, and the explanations made since, is that it is advisable to support the load entirely on the center plate. Efforts to do this, however, have met with failure in many instances, and when such is the case it is entirely fair to question whether it is better to entail considerable expense in providing amply stiff bolsters or to carry a part of the load on the side bearings, and to provide side bearings which shall have as little friction as possible. Having taken the position that the present general practice of framing cars could be changed so as to distribute the load to the bolsters, the body bolster in particular, in a way that would be more favorable to the bolsters, it seems incumbent to present such ideas to the Club for the benefit of the members, if the ideas are correct, and for the benefit of the author if the ideas are wrong.

It is necessary, in making calculations of the strength of the parts of a car, to assume a particular loading, and while it is impossible to cover the many different loadings to which cars in general traffic may be subjected, nevertheless if a fair average method of loading is assumed, and provision is made for a liberal factor of safety, it is quite certain that there will be experienced much less difficulty than at present from springing bolsters and racked framing.

THE TRUCK BOLSTER: Beyond providing a bolster sufficiently stiff vertically to carry the loads imposed, and sufficiently stiff crosswise to resist shocks received lengthwise of the car, little can be done. This bolster is simply a beam

supported at both ends and loaded in the middle; the length of the beam may be changed, but as the springs are moved in from the side frames and supported on transoms, as with the swing motion type, then the transoms must be made correspondingly heavier as the bolster becomes shorter and lighter. Considered in a general way, it is easier to provide a substantial truck bolster which will give satisfaction mechanically and commercially, than to provide a body bolster which shall be satisfactory both commercially and mechanically, because there is more room available for the truck bolster, and the truck bolster is generally shorter than the body bolster. This is the principal reason why more rapid progress has been made in the design and adoption of a satisfactory truck bolster than of a satisfactory body bolster, and the result has been the very common error of putting a substantial truck bolster under a very weak body bolster; cars so equipped are running with side bearings just as firmly in contact as would be the case were both the body and truck bolsters of the previous weak design.

THE BODY BOLSTER: At the present time the weakest part of the car is the body bolster; in a few designs the strength of the sills or of the draft

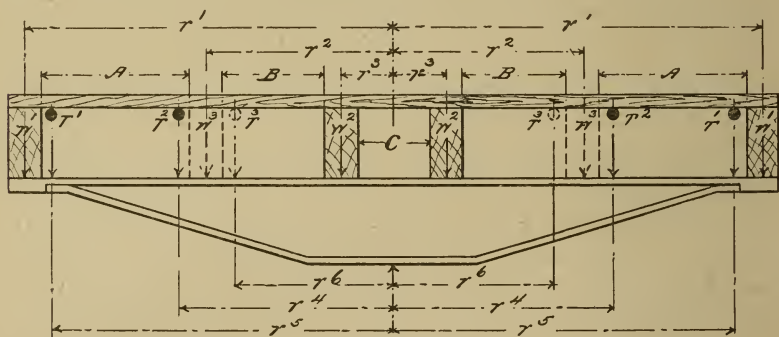


FIG. 1.

timbers has been sacrificed in an effort to make room for a stiffer body bolster, and on this account it might be better to qualify the declaration and say that the cars at present are weakest at the body bolster. Obviously, were it possible to deliver the entire load to the body bolster on the surface immediately above the center plate there would be no difficulty in providing a bolster amply strong to carry the heaviest car loads now even thought of; therefore, it must be of much advantage to deliver the load to the bolster as near the center plate as possible, and an effort will be made to show how the usual arrangement of sills, truss rods, needle beams, and upper framing can be changed and the result be favorable to the body bolster. Fig. 1 shows a very common distribution of the load on the bolster; the center sills are placed close together in order to receive the buffing strains, and also because the draft timbers are usually located immediately beneath them, and the proximity of the timbers facilitates the attaching of the draft rigging; the side sills are, of course, placed at the extreme ends of the bolster, or, better, the bolster extends the full width of the

framing; the two or four, as the case may be, intermediate sills are located in such a way as to give proper support to the flooring, and the truss rods are generally located as shown in the full lines. The locations of the center and side sills are therefore fixed by conditions which are not strictly under the control of the designer, and there is no alternative but to place them in the usual position. The center sills being directly above the center plates, the part of the load carried by them is transmitted to the bolster at the place most favorable to the bolster, and every means possible should be adopted to load them to their full capacity and make them as heavy as it proves expedient; the load carried by the side sills is transmitted to the bolster most disadvantageously, and, therefore, just as little of the load as possible should be carried by the side sills.

LOCATION OF SILLS: It will be understood from the above that, in so far as the position on the bolster, of the center and side sills is concerned, it is probable that nothing can be done to favor the bolster; this assumes that the width of the car is fixed, and that any improvement which is to be wrought through these sills must be gained through manipulating other parts, to the end of decreasing the percentage of the total load carried by the side sills, and increasing the percentage of the total load carried by the center sills; several ways of accomplishing this will be given in the following: There are several conditions to be considered when determining the location of the intermediate sills, the most important of which is the proper support of the floor between the center and side sills; assuming that the sills rest directly on the bolster and that no truss rods, or needle beams, or other means than the flooring, is used to distribute the load to the sills, and disregarding the weight of the sills, the location of the intermediate sills affects in no way the maximum moment produced by the load on the bolster so that, assuming that there is clearance for wheels, rods and pipes beneath the car, these sills should be placed at equal distance from side and center sills in order to give proper support to the flooring; so far as reducing the maximum moment is concerned, the intermediate sills might as well be left out; the use of them neither reduces nor increases the stresses on the center section of the bolsters. It is not difficult to calculate the fibre strains of a body bolster, but it is quite difficult to calculate the deflection which will result from an assumed loading, if there be more than one sill at each side of the center, and it is not certain, even, whether a satisfactory formula has been developed from which to calculate such deflection. The fibre strains are calculated by formula for the strength of cantilevers, the body bolster being such a structure, with the strains at the center directly opposite and equal.

The bolster should be made as deep as possible at the middle, and proportioned accordingly throughout its length, and when the most favorable distribution of the loading to the bolster is found, as will be explained, by the moment of forces about the center, the stresses in the top and bottom members of the bolsters may be calculated and the parts proportioned accordingly. The moments about the center are found by multiplying that part of the load which is delivered to the bolster by each sill and truss rod, by the distance of each from center of the bolster. For example, referring to Fig. 1, the total

moment at the center is equal to $(W^1 \times r^1) + (W^2 \times r^2) + (W^3 \times r^2) + (T^1 \times r^5) + (T^2 \times r^4) + (T^3 \times r^6)$, where the "W's" and "T's" represent loads transmitted by the sills and truss rods respectively, and the "r's" are the respective distances of each sill or truss rod from the center. (In calculating the strength of the bolster it is necessary only to consider one-half of it.) The duty of the designer, therefore, is to so locate the sills and rods, and other parts of the framing, that the total moment at the center of the bolster, calculated as above, shall be as small as possible. If the declaration, that the location of the intermediate sills does not affect the moments at the center of the bolster, on the assumption that the load is uniformly distributed and the sills of equal section, and the weight of the sills being disregarded, is doubted, it may be quickly proven by assuming a location for the side and center sills, and then, for various locations of the intermediate sills, calculating the moments at the center; in such calculations the truss rods need not be considered.

THE TRUSS RODS: The load on the truss rods is transmitted to them through the needle beams, or cross center sills, and is transmitted by them to the body bolster. Disregard, for the present, the means by which the truss rods receive their load near the middle of their length; given the diameter and number of rods and the angle which they make with the horizontal or vertical the load which each will transmit to the bolster can be calculated from a quite common formula. Assume that there are two truss rods each side of the center of the car, that they are located at T^1 and T^2 , Fig. 1, a very common arrangement, and that the vertical component of the stress in each is 5,000 pounds; assume, further, that the distance from center of bolster to T^1 is 50 inches, and to T^2 is 35 inches, then the moment of each at the center of the bolster is:

For T^1 , $5,000 \times 50$ equals 250,000 inch-pounds.

" T^2 , $5,000 \times 35$ equals 175,000 " "

A total at the center of...425,000 " "

or the equivalent of 425,000 pounds applied 1 inch from the center of the bolster, or about 35,400 pounds placed 1 foot from the center. Assume, now, that the truss rods are located at T^2 and T^3 , the latter being 30 inches from the center, a very reasonable location; then the moments at the center are:

For T^2 , $5,000 \times 35$ equals 175,000 inch-pounds.

" T^3 , $5,000 \times 30$ equals 150,000 " "

A total at the center of...325,000 " "

or the equivalent of 325,000 pounds placed 1 inch from the center, or about 27,000 pounds placed 1 foot from the center.

The error must not be made of assuming that the improved condition is always as great as would be indicated by the difference of the two total moments given above; this amount and, in some cases, more can be gained by suitable arrangement, but the method of attaching the needle beams and the designs of them must be suitable if so much improvement is to be made.

THE NEEDLE BEAMS: Reference will be made to Fig. 2 in explanation. Ordinarily, all the sills rest on the needle beams, and Fig. 2 will show that although the needle beams may transmit a part of the load from the side sills to

the truss rods, and the latter deliver the same nearer to the center of the bolster, there may be a considerable part of the load from the center sills similarly transferred to the truss rods, and by them delivered to the bolster at a point farther from the center of the bolster than would be the case were no trussing used. Now, as to how the advantage indicated above, or a greater advantage, may be gained. It is clear that the side sills should rest on the needle beams, and the latter on the truss rods, and that the nearer the center of the bolster the truss rods are supported, provided they are loaded the same under various conditions, the better for the bolster. It is quite certain that the center sills should not be supported on the same needle beams and truss rods, unless indeed, the truss rods are located inside of the center sills, or the needle beams are sufficiently stiff to carry the load of the side sills without bending upward between the truss rods. This leads to the general statement that, in order to favor the bolster as much as possible through the medium of the truss, the rods should be placed far inside, that is toward the middle of the bolsters, of the sills on which the rods act as trusses, as the strength of the other parts will allow. The other parts referred to are the end sills and the needle beams, both of which are used to distribute the trussing over all the sills.

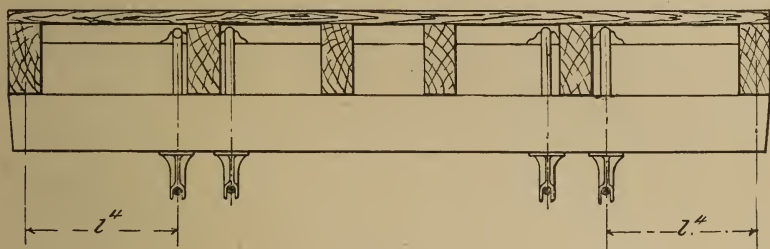


FIG. 2.

It will probably be considered inexpedient to do all the trussing with rods placed between the center sills; nevertheless it is quite possible to place one truss rod immediately outside of each sill and this will not be contrary to the general statement made above, because rods so placed will, generally, rest on the bolster within the radius of the bearing surface of the center plate. This will suggest two arrangements, viz: one, that the center sills do not bear on the needle beams, but that these sills be trussed independently of the main needle beams by means of secondary needle beams extending, to advantage across the intermediate sills. With such an arrangement, however, dependence must be placed in the flooring, to make the sills act together, or other desirable means should be provided for the same purpose. The second, and probably the better method, is to locate a truss rod either inside or just outside of each center sill, and another truss rod at the inside of each intermediate sill, or even closer to the center of the bolster if found expedient to do so, all four truss rods to bear on the two needle beams, as is ordinarily the case, but these beams to be designed so stiff that they will not bend between the two outside truss rods with the load imposed by the side and intermediate sills.

THE END SILLS: Unless some consideration has been given the question, it may be difficult to understand "at a glance" how the end sills can be used to change the distribution of the load on the bolsters, and it may be necessary to explain this still further. The advantage derived from trussing the longitudinal sills is due to the fact that when trussed, these sills carry the load partly as columns and partly as untrussed beams; in order to take advantage of the former principle, it is necessary to provide the strut or struts in the middle, the needle beams, and to distribute the truss rod strains over the ends of the longitudinal sills so as to put these sills in compression.

In freight equipment it is usual to extend the truss rods to the outer face of the end sills and distribute over the ends of longitudinal sills, by means of the end sills, the stresses incident to the use of the rods; the end sills, therefore, must be of sufficient stiffness to make the distribution properly. Therefore, as the truss rods are moved toward the middle of the car, the end sills must be made correspondingly heavier. The ends of the end sills, extending from the truss rods to the side sills, are of the same class beam as the needle beams, and calculation for the strength of each is made in the same way, and any change in one, made necessary by change in location of the truss rods, must quite certainly be provided for in the other.

THE UPPER FRAMING: If the car under consideration has an upper framing, unless there is something different from ordinary car construction there is not much that can be done with it that will affect the bolster. The side frames probably cannot be manipulated to affect the distribution on the bolster, but it is possible to adjust the end framing to advantage. For instance, the diagonal bracing at the ends generally extends from the upper end of the end posts, or from near the middle of the end plates, to the lower end of the corner posts; these braces are compression members, the connections being made in such a manner that if the braces assist in carrying the roof load to the sills they must be in compression, and are, therefore, transmitting some of the load, which would naturally be transmitted to the center sills, to the side sills. If it is considered necessary to put in these braces in the usual manner, rods extending parallel with them and adjacent to them might be secured to side sills and to the end plates near the middle of them, and through these and the end posts a part of the load overhanging the side sills be transferred to the overhang of the center and intermediate sills.

In the reference to the longitudinal sills above, it has been assumed that all the sills were of equal section; sometimes some of the sills are made of heavier section than the others, and quite generally the side sills have been selected for such increase; there are occasions when there is no choice, only to make the side sills the heavy ones, but this should not be done when it is possible to gain the same advantage by making the center, preferably, or the intermediate sills the heavy ones. If some sills are to carry heavier loads than others, such heavier sills should be located as near the middle of the bolsters as possible. By suitable connections between the sills and the needle beams, the heavier and stiffer sills can be used to advantage, even to assist in supporting lighter outside sills. Many of the remarks made above will apply equally well to cars designed for special loading; as, for instance, such cars as are designed for

loading suspended from the roof. The side sills of such cars are heavily taxed, and because the sills deliver the load at the extreme ends of the bolsters, use should be made of everything that will assist in delivering the load to the bolster at a point nearer the middle. If some sills are lighter than others, and the lighter ones spring sufficiently to get out of line with the others, or bend downward, then the flooring may affect the distribution of the load to the bolsters; if the side sills deflect more than the other sills the flooring will transmit to the intermediate sills a larger portion of the load than did all sills deflect together, and this would favor the body bolsters. Contrary would be the case were the side sills the very stiff ones. If the center or the intermediate sills are made heavier than the side sills then a thicker flooring may assist in relieving the side sills of a part of their normal load, especially if the side sills bend slightly, and acting as a cantilever transmit a part of the overhanging load to the inner sills, the result being favorable to the bolster.

THE CHAIRMAN: Mr. Whyte will open the discussion on the paper, as is customary for the writer to do.

MR. WHYTE: The purpose of the paper is explained quite fully in the first sentence of it. The position which I took in the discussion at the May, 1898, meeting, was, that the different parts of the under framing of cars might be manipulated in such a way as to assist the body bolster. The principal way in which the body bolster can be assisted is, of course, to make the cars as narrow as possible, so as not to get the load distributed over a long bolster; but, in order to carry a certain weight, the height or length must increase as the width decreases, and there are limits in height and desirable length just as there is a limit to the width. So that throughout the paper the object in view has been to show how the different parts might be manipulated to carry the load nearer the center of the body bolster, the body bolster being particularly the weak part, as is explained in the first sentence under the side heading, "Body Bolster." It has been said that, on account of the limited space available for the body bolster, this part of the car cannot be made sufficiently stiff to carry the increased loads now imposed. While preparing the paper there were kept in mind the conditions that the loading should be uniformly distributed, as is a load of wheat or coal, or similar material, and the weight of the sills themselves was disregarded, so that where it is said that no matter what the location of the intermediate sills may be, the resulting momentum at the center of the bolster is the same, the declaration is limited entirely to these conditions. If the weight of the sills is considered, then, of course, the intermediate sills should be placed as near the center sills as possible.

It might have been said, in the paragraph refering to longitudinal sills, that if the center or the intermediate sills were made heavier than the side sills, the side sills might deflect below the center and intermediate sills, and that under these conditions and with a heavier flooring a greater part of the load would be distributed to the intermediate and center sills, the bolster being assisted somewhat in this way. You should not be led astray by the calculations, or result of the calculations, under the side heading "Truss Rods." Certain figures are given there which relate to the center of the bolster and which, on account of the general construction of cars, do not exactly apply, because the bending moment does not take place directly on a knife edge at the center; the center sills are separated some distance and the center plate being directly under them and having a wide bearing, the maximum moment is not so exactly centralized as would be the case were the bearing a knife edge; they do show, however, in a general way what improvements can be made.

Under the head of "Needle Beams" I may remark that objection has been raised to the suggestion that four needle beams, instead of two, be used. The principal object in view in making that declaration, was to call attention to the fact that the needle beams should be particularly stiff, if only two are used, so that the load on the center sills will not be distributed through the needle beams out to the truss rods in equal amount to what is transferred from the side sills in to the truss rods. The suggestion made is, that either two independent sets of needle beams be used with one set bearing on the center sills and, probably, the intermediate sills also, and the other set bearing only on the side sills, the needle beams which carry the side sills being notched out directly under the center sills, so that the center sills could have no bearing on them. I think it would be just as well, however, to make a particularly stiff needle beam and let it bear on all the sills. This would be the better plan, certainly, if truss rods were placed between the center sills.

THE CHAIRMAN: Gentlemen, the paper is now before you and open for discussion. I hope you will all feel free to speak on it.

MR. G. W. SCOTT (Pullman Company): The subject of the most economical application of material in the framing of cars is one of deep interest, whether it be viewed from the standpoint of the so-called purely theoretical, or from the point of view of one who,

while keenly alive to the end and purpose of matters mechanical, is no less conscious of the commercial interests involved. To the latter, a car is something more than an assemblage of material on wheels—it is an appliance to be built and operated as an item associated with and for the purpose of transporting people or things; and in its vital significance it is a means by which its owners and operators expect to reap a more or less adequate pecuniary or substantial return for their efforts in time, money and labor. While to many this reference to the financial consideration may be commonplace in the extreme, its recognition here is desirable in view of a comprehensive grasp of the subject under discussion. For related to it is the forcible truth that the first cost of a car is by no means its entire cost; but that following such initial expenditure there is, throughout the life of the car, a succession of additional charges for repairs and maintenance, the frequency or rather occasion of which, apart from accidents, is dependent on the strength of the car to withstand the rough usage which it may and probably will receive. With this in mind, it goes without saying that that car will be the more economical in cost and maintenance which, for a given service, has the materials of which it is constructed more correctly selected and applied than in a less favorable instance. It may thus be seen that in the all important question of first cost and maintenance for cars there is much that is extremely pertinent in the subject before us; and it may also be recognized that by the application of correct measures in the design and construction of cars, much that is objectionable may be avoided, and, conversely, much that is profitable secured.

In his treatment of the subject, Mr. Whyte works from the truck upwards. He claims, and I think very properly, that whatever may be the nature of the truck, the car with its contained load should be borne upon the center plates entirely free from any assistance from the side bearings. And while he does not make the direct statement, I can imagine that he regards the side bearings merely in the light of limit stops to the oscillatory motion of the car. Even as it is, and as Mr. Whyte declares, the side bearings in many instances become actual bearing surfaces in constant contact, and what was supposed to be a simple stop to the rocking motion of the car, becomes an area subjected to an appreciable load, with its consequential frictional resistance during the motion of the truck with respect to the body.

It surely may be taken for granted that so long as cars are necessarily associated with center bearing trucks, that the only correct position for the application of the body and its load is upon the truck center plates. And if this is accepted, Mr. Whyte's contention that "it must be of much advantage to deliver the load to the (body) bolster as near the center plate as possible," must also be accepted. Mr. Whyte has brought some figures to bear upon the question, and by them affords evidence of the correctness of the position taken. The question is one that readily admits of mathematical treatment; but even in its general character, quite apart from any analysis, the correctness of the proposition is self-evident; and in this respect one need not argue beyond the fundamental and well-nigh axiomatic consideration that in any structure the most economical disposition of the material is realized when the lines of forces (or loads) are in direct opposition to the re-actionary points or surfaces.

It is true that a car bottom with its associated trucks is not the simplest possible illustration of the last mentioned statement; but the case is susceptible of very close treatment. For example, Mr. Whyte has demonstrated that in the ordinary form of car floor framing consisting of center, side, and intermediate sills, with associated truss rods, the bending moment in the case of the body bolster may be appreciably reduced by locating the truss rods on the outside of the center and intermediate sills, or generally nearer the center than is ordinarily the case. Now for the purpose of a broad illustration we may go further than this, and we shall be well within the limits of logical reasoning if we conceive the six or eight sills to be furnished with adequate needle beams, but associated with only one truss rod, and that located in the center with its attachment or bearing in the center line through the center plates. Of course, there are some very potent reasons why this application could not very well be made—the king pin and draft rigging for instance—but the case is complete in its figurative sense, for no one will question the possibility of such a combination of needle beams or struts and single truss rod, all capable of supporting such loads as those in question. Were such a case possible in its practical application, Mr. Whyte would find in it the idealization of his proposition; for under such conditions the stresses from the truss rod would be applied directly over the center plates, and thus entirely free from producing any bending moment at all in the body bolster. So much, then, for the logical

extension of the question, and its proof of the correctness of the point in debate.

But while the foregoing is all very true, it must not be lost sight of that in placing the truss rods nearer to the longitudinal center line of the car (in plan), and loading them to a greater extent than is commonly the case, there will follow the inevitable necessity for increasing the strength and stiffness of the needle beams, or struts. Such a conclusion might, indeed, be anticipated; for if we are to take a portion of the load from the side and intermediate sills, and apply it at a point appreciably nearer the center of the center plates than the distances now commonly employed, this being involved in Mr. Whyte's question, it is very clear that while we may succeed in decreasing the bending moment of the body bolster, we shall just as surely increase the bending moment in the case of the needle beams. It may thus be seen that in the final analysis of this portion of the subject, the solution will be found not far removed from commercial dictates. That is to say, the extra cost for suitable needle beams will be compared with the extra cost for body bolsters correctly designed and sufficient in strength for the loads likely to come upon them.

Upper Framing: In this respect I am inclined to think that it is not correct to consider the upper, or side, framing of a car as forming any substantial element in the strength of the general structure. The conclusion is based on the limitation of the material consequent upon the several openings for doorways or windows. At all events, I hold that the floor of the car—freight, passenger, mail, or baggage—should be designed and constructed to carry the total load of the body of the car and its contents, and that the sides, ends and roof should be considered wholly with reference to the specific purpose of each. Necessarily, the upper structure should be at least sufficiently strong to withstand the stresses due to shifting loads, track irregularities, inertia, wind, and other sources of shock.

That there is room for the thought of a self-sustaining floor, and one capable of carrying the whole of the load, is abundantly proven by the existing order of things. In witness whereof, let me instance the items of drooping platforms, sagging floors, and creaking bodies, all of which are familiar enough to those concerned with the building or operating of cars. But even if one's zeal should lead him in the direction of relying upon the upper structure for general stiffness, would it not be well to see to it that all such effort is not rendered

abortive by the seemingly reckless manner in which some doorways are incorrectly placed, and others lacking in suitable reinforcement? And what shall be said of the equally obvious error of placing a compression member where its action is productive of a bending moment in some portion of the side sills least able to bear such strain? Clearly, such matters would be appreciably less detrimental in the case of a car having a self-sustaining floor.

One may design a machine, a boiler, or an engine, with some degree of assurance as to the load which will be encountered; but not so sure is the work of the one whose duty it is to design a car. In this case he is dependent much upon precedent; the loads are mainly assumptive, and the factor of safety used may or may not be sufficiently large to cover the reckless loading or handling which may at some time be dealt the car. But while this is only too true, the general practice of car building is far from being an altogether speculative one; there is stored up in the collective minds of car builders at large a wealth of added experience, and every day increases the range of the scientific consideration of car building—a subject wonderfully fascinating, despite its many ever pressing details and time absorbing cares.

PROF. W. K. HATT (Purdue University): The possibility of carrying part of the weight of the car and its loading to act nearer the center of the body bolster must be admitted. As Mr. Whyte has just remarked, an intermediate sill, which is made stiffer than the other sills, will carry a relatively larger proportion of the load, in accordance with the general principle that when two or more members transmit loading to a support, the different members take amounts of the load in proportion to their respective stiffness. Nor does the use of truss rods change the matter.

The effect on the other parts of the car structure, of stiffening the intermediate sill, is not touched upon by Mr. Whyte. But whatever may be the distribution of the load on the bolster, and no matter how this distribution may be effected, it is necessary to determine the deflection of the bolster at the side bearing.

Now the problem of computing the deflection of a beam is simple enough when the flanges of the beam are parallel. When the flanges run together at the end, as indeed they do in some forms of bolster, or when the depth of the bolster decreases from the center to

some depth less than the center depth at the end, the problem is somewhat complex. As Mr. Whyte remarks, no formula exists to fit the latter case.

The speaker has developed a formula to fit this latter case, and has applied it to a number of forms of bolster. He has also made tests of a few forms of metal bolster in the laboratory of Purdue University. It may be remarked that the results of tests agree with the results of computation from the formula.

The Club may be interested to know the results as representing present conditions.

Tests: A metal body bolster tested with a loading equivalent to 80,000 lbs., uniformly distributed, had a deflection of $\frac{1}{8}$ -inch at the side bearing.

A metal truck bolster of 75 inches span deflected $\frac{1}{8}$ -inch under a center load of 80,000 lbs. Another metal truck bolster of 55 inches span deflected 1-32-inch under 80,000 lbs. center load.

Some years ago the Master Car Builders' Association instituted tests on wooden truck bolsters. Under a load of 25,000 lbs. these bolsters deflected from 0.2 to 0.4 inches in a span of 54 inches. One trussed bolster, of span 75 inches, deflected 0.12 inches; and one bolster which had been in service two years deflected 1.4 inches. The latter deflection was probably due to looseness of parts.

Computation: Passing to metal truck bolsters, resting on springs, computation of deflection in case of six selected bolsters results in a deflection of about 1-10-inch under 80,000 lb. load.

Again, three rigid truck bolsters (center depth 12 inches), showed a deflection of $\frac{1}{16}$ inches in a length of 75 inches under center load of 80,000 lbs. Two others (center depth about $16\frac{1}{2}$ inches), under same conditions had a deflection of $\frac{1}{32}$ inches. In case of these rigid truck bolsters, the partial fixity of the ends was neglected in computation.

Again, a body bolster designed for a 100,000 lb. car had a computed deflection of $\frac{1}{1000}$ inches under a load of 80,000 lbs. The truck bolster for the same car had a computed deflection of $\frac{3}{32}$ inches.

It must be remarked that all these computed deflections are elastic deflections due to bending. They need be increased to account for inelastic deflection—i. e., that due to looseness of parts. In case of bolsters with web plates, there will be a slight additional deflection due to shear, probably not more than one-quarter part.

The elastic limit of the truck bolsters corresponds to a center load of from 100,000 lbs. to 160,000 lbs. The range of center depth is from 10 to 13½ inches in case of bolsters resting on springs; and from 12 to 17¼ inches in case of rigid truck bolsters.

The elastic limit of the two body bolsters examined correspond to a uniformly distributed load of 60,000 lbs. Taking the live load effect as double that of the dead load, it would seem that these body bolsters do not possess reserve strength to the same degree as do the truck bolsters. The difficulty, of course, to obtain a sufficiently stiff bolster with the limited depth at the command of the designer.

It is evidently true in case of bolsters, as it is true in case of brake beams, that the strength and stiffness of structures designed for identical service seem to be dependent on the judgment of the designer rather than on any rational or formal process of computation.

The formula for the deflection at the end of a bolster of I section loaded with uniform load is:

$$\delta_o = \frac{wl^4}{2(I-I_o)} \left[\frac{1}{3} - \frac{c}{2} + C^2 + C^3 \log_e \frac{I'}{I_o} \right]$$

The deflection at the side bearing d is about 40 per cent. of this, where w =load in pounds per running inch.

I' = moment of inertia at center.

I_o = moment of inertia at end.

A corresponding formula for the deflection at the end of a bolster loaded with a terminal load= P is:

$$\delta_o = \frac{Pl^3}{I-I_o} \left[\frac{1}{2} - C + C^2 \left[\log I' - \log I_o \right] \right]$$

These formulæ are developed in the *Railroad Gazette* for December 16, 1898.

In the *Journal of the Franklin Institute* for September, 1898, will be found a formula, developed by Prof. I. P. Church, to fit the case of a truck bolster composed of an upper compression member and a lower tension member.

MR. JAS. W. HILL (P. & P. U. Ry.): It is a well known fact that a large number of cars running at the present day have body bolsters too weak to carry the load, and that the side bearings are carrying so much weight that the cars will not curve easily. As a consequence, much more power is required to pull a train on curves than would be required if less weight were carried on the side bearings. I think, however, at the present time the tendency is to strengthen the body bolsters. The suggestion made in the paper under discussion, in regard to carrying the body truss rods nearer the center of the car and using stiffer needle beams or cross-tie timbers is a good one. For some time I have been doing away with king posts entirely on the needle beams and have been putting in deep needle beams, using a small iron saddle to carry the body truss rods on the lower face of these beams. This I consider a better construction for any class of cars, and particularly so for gondola cars, as it permits a long bearing for two very heavy stakes on each side of the car, thus preventing the bulging out of the sides of the car when heavily loaded. It also prevents the turning out of the side sills where a rod is carried through the sills from one side of the car to the other, just below the floor near these large stakes. Of course the carrying of the body truss rods nearer the center of the car and the consequent carrying of more of the load nearer the center plate on the body bolster is a great advantage and helps to remove the load from the side bearings. On passenger cars where four body truss rods are used, it is also very important to have very stiff needle beams to prevent the two center truss rods from humping the floor up in the center. In my opinion, it is a good plan to truss these needle beams on passenger cars over the top edge to prevent tendency to spring up in the center.

MR. A. M. WAITT (L. S. & M. S. Ry.): When a debate somewhat similar to this came up at one of our previous meetings, in May, 1898, I made some remarks that created considerable comment and antagonism. They were based upon an examination of quite a large number of wooden framed cars, nearly every one of which cars were found to have the side bearings in contact and transmitting quite a large portion of the load through the side bearings. I had at that time been unable to find any wooden or steel-car-construction body bolster for cars 60,000 pounds and upwards of capacity, stiff enough to carry the car at all times free from the side bearings. At the time

of the May meeting, I suggested that it was a subject worthy of a good deal of consideration, as to whether it would not be an ideal way of carrying the loads distributed between the center plate and the side bearings. That suggestion was made in view of the fact that body bolsters had not been made stiff enough to carry the cars at all times free of the side bearings. I have given that subject the consideration that I suggested, and I am satisfied that if it is possible and practical to have a body bolster which is stiff enough to carry the load so that it can be transmitted to the truck at the center plate, that, undoubtedly, is the ideal and proper way to carry it; but last week I had occasion to spend two days or so, cruising around in the various railroad yards in the vicinity of Pittsburg to see among other things, what had been accomplished in the way of making body bolsters for steel cars. I looked over a great many cars, the number running up into the hundreds, cars of 80,000 pounds capacity and some of 100,000 pounds capacity, and in no style of construction was I able to find an average of more than five cars out of ten where the body bolsters under load were stiff enough to keep the side bearings apart. It has been assumed, I think quite generally, that with these heavy steel cars this object has been accomplished. In some cases the side bearings were clear, and others on cars of the same construction were down. So I believe that we have not yet, in any form of construction which I have seen, arrived at a body bolster that is stiff enough. But even if we should find such a bolster, we know that it is practically impossible to always trim a load perfectly even. The load will be more on one side than the other, and consequently the side bearings will be in contact on one side. In going around a curve the centrifugal force will throw the side bearings in contact on the outside of the curve. So that I think it is going to be necessary, even though we have an ideally stiff body bolster, to provide some help against friction when the cars are on a curve or when the load is unevenly distributed. I think it is theoretically and practically true, that in designing a car, either of wood or of steel, as much of the load as possible should be distributed along the central line connecting the supports. That would be distributing the load as far as possible to the center sills. In order to do that, it would seem necessary to give a great deal more attention to the needle beams, or cross-tie timbers, as we speak of them in the Master Car Builders' dictionary, than has been given in the past. The name cross-tie tim-

bers seems to indicate the use to which that timber has in the past been put, that of tying the frame together. It seems to me that it should play as important a part in supporting or distributing the load from the outer sills to the center as the body bolster does. I notice in some designs of steel car construction that have been submitted to the Master Car Builders' Association, the designers have evidently figured to transmit the load that is on the side sill to the center sills, and from the center sills to the center plates and truck. It seems to me that is the ideal form of construction for cars. It is somewhat more difficult to do that with the wooden car construction than with the steel. With the steel car construction, I think the tendency is to have very heavy and deep center sills. It is not always practicable to have them so stiff in the wooden construction, and especially where the capacity of cars is being raised from 60,000 pounds to 80,000 and 100,000 pounds capacity. In the past, when we had light capacities of cars, the design of a car was not a matter that called for so much careful consideration and design as at present, and I believe we have got to come to the position of giving a scientific and theoretical consideration to car designing as we have never done in the past; by doing so, we will have the greatest carrying capacity with the least amount of material used. I believe that the study in that direction is going to lead to the abandonment of much of our wooden construction because with cars of heavier capacity the combinations necessary will be much heavier, and we will have more of a dead load as compared with the carrying load than we would have considering the possibilities of steel in the construction of cars. I am very glad this subject has come up, and I am glad so many have given thought to it; I think it will result in having better designed cars, be they of wood or be they of steel.

MR. G. W. SHOWERS (Canda Cattle Car Co.): I had occasion to make an experiment a short time ago. Our cars have the weight exclusively upon the side bearings, allowing 8 inches from outer truss rod to the end of the body bolster. The truss rod was $3\frac{1}{2}$ inches from the inside of the side sill. I have found these cars after running six or eight months with body bolster, which is wooden, 5 x 14 inches, down almost three-quarters of an inch. I made a change in these cars by taking the truss rod from the space between the intermediate sill and side sill, and placing it nearer the intermediate sill and nearer the center of the car, and those cars on which I made the

change, with the same size needle beam, have not gone down a particle; that much in favor of truss rods being nearer the center plates.

MR. F. A. DELANO (C., B. & Q. R. R.): I should like to ask Prof. Hatt to describe a little more fully how these tests were made, with a view to understanding better how the loads were applied. I think that in the matter of the test of body bolsters that would be quite difficult.

PROF. HATT: The method of testing the body bolster was as follows: The bolster was supported at the ends, and loaded with 20,000 lbs. at the center; and the deflection of the side bearing determined. The supports were then moved in to correspond with the position of the first intermediate sill, and the deflection at side bearing again determined for 20,000 lb. center load. The operation was repeated for each sill.

Since the deflections are small, and are all within the elastic limit, we may take the deflection due to the combined effect of the loadings as equal to the sum of the deflections observed when the part loadings were applied.

PROF. W. F. M. GOSS (Purdue University): Mr. Chairman: The discussion this afternoon naturally recalls a similar discussion which came up at a meeting last spring. It is important, however, to bear in mind that the present discussion has an origin which is quite different from that upon which the earlier discussion was based. The question last spring was whether we should design cars to carry at all times a part of their load on side bearings. This proposition should not be confused with any question concerning the efficiency of side bearings. The one question is fundamental in car design, the other deals with a matter of detail.

The side bearing, as I understand it, is designed simply to limit the rocking motion of the car, but, as a matter of fact, under present conditions, it often does more than this. I think there can be no question but that to perform its legitimate office, as well as to receive the unusual stresses, which through the drooping of the body bolster comes upon it, the side bearings should be improved. They have an office to fill which is important, and they should be made to meet the conditions of that office in the best possible manner. Just how they should be improved I am not prepared to say, but the need is apparent.

While I believe in better side bearings, I am not ready to admit

that it is necessary to have such side bearings permanently loaded. I admit that there are difficulties in making a stiff body bolster, but Professor Hatt has shown that such bolsters are already to be had, which, when loaded to twice their normal load, deflect but one-tenth of an inch, and Mr. Whyte's argument shows that something can be done to relieve the bending stresses on the bolsters. The steel bolster is certainly stiffer than the old wooden ones, and as experience is had with those of the present design there can be no question but that heavier and stiffer bolsters will be employed. I think the discussion this afternoon is sufficient to prove that we are making progress in the right direction, and that the side bearing will continue to be an incidental rather than the principal support for the body bolster.

MR. J. R. CARDWELL (American Cotton Oil Co.): In visiting a number of car shops recently, I noticed light body bolsters being applied to freight cars, with very heavy truss rods near the outside of the car. In following up our paper, and in pursuance of the ideas presented, I would like to ask why it would not be wise to place the truss rods nearer the center of the car? We know that a considerable amount of the load is transferred from the bearings of the longitudinal sills on the body bolster to the seat of the truss rods, regardless of their location. The extent of the load given this new bearing, of course depends upon the strength of the truss, but with a strong enough truss and deep enough angle, a considerable portion is thus transferred. Now the needle beams can be straightened vertically a great deal easier than the body bolster, and if the needle beams are of sufficient stiffness to transmit to the side or outer longitudinal sills their proportion of the upward force of the truss rods, the truss rods can be placed nearer the center of the car, which, following up the line of figuring presented in our paper, will very greatly reduce the moments of force at the center of the body bolster.

MR. E. E. RUSSELL TRATMAN (*Engineering News*): It seems to me that, mechanically, the proper way is to carry the load on the three bearings. I know that this is not generally accepted, but it seems to me that the enormous load carried in our modern car, as, for instance, the coal cars of 80,000 pounds capacity on the Illinois Central railroad need something more than one point to carry it upon the truck. You are pretty sure to get it on more than one point, in practice, and it seems to me it would be better to design the car to

carry it there permanently. A great deal is often said against putting rollers into these side bearings, on the ground that they would not work, but would rust and get clogged up. The roller bearings used under the ends of bridges can be taken as an example of that. They used to have a great deal of trouble with them, until they put in what are called sectional rollers, or rockers, which are not complete rollers but sections of rollers of much larger diameter than the circular rollers ordinarily used. These, of course, move much more freely than the ordinary small rollers. I am not suggesting any special design of side bearings, but it seems to me that a small roller is not an absolute necessity for a permanent side bearing. Of course, at the same time a stiff body bolster is wanted, to prevent getting too much load upon the side bearings. Most of the load should be carried at the center, but there should be provided also a permanent bearing for the side of the car, which will take a certain proportion of the load.

As to the steel cars going down on the side bearings, as mentioned by Mr. Waite, some of the steel cars now in service have body bolsters which are discontinuous, that is, they are merely short pieces of bolsters, sandwiched in between the sills, and depending entirely on the rivets to hold them in position. With any defective work on those, I should think the first thing they would do under a heavy load would be to go down on the side bearings, especially as they are intended to carry about fifty tons of paying load.

MR. P. H. PECK (C. & W. I. Ry.): I think as our cars are made larger and the loads imposed are heavier there will be more attention paid to the side bearings. I think we can trace a great many of our derailments to side bearings having too much friction. A heavy car coming off a side track, for instance, on to a short curve, with a great deal of elevation, there are times that one side bearing will carry all the weight of the end of the car; the load will be entirely off the center; the rear truck will be on the elevation, and the front truck on the level track between the frog and the switch point. On the short radius curves in the city there are a great many cars derailed, and I think the cause is as stated above. I have seen cars running very slowly and none of the weight on the centerplate; no matter how equally distributed the load is, there are times when the side bearing will carry all the load. I think that many of the side bearings in use are not desirable for the purpose for which they are intended.

THE CHAIRMAN: Many of us are putting in truck bolsters, and paying little attention to the body bolsters. I have noticed many cars in which the sills were rounded up on account of the truck bolster being stiffer than the body bolster. We have got to pay more attention to the body bolster. If there is no further discussion on this, the debate will be closed by Mr. Whyte.

MR. WHYTE: Mr. Chairman, it has been suggested, either directly or indirectly, that it is impossible to carry the loads, or to assist in carrying more of the loads, with the truss rods and needle beams, without increasing the size of these parts. This is true, but it is generally understood that it is impossible to increase the strength of the body bolster without going to considerable expense, and an investigation should be made in each case, to determine whether the cost of increasing the size of the needle beams and truss rods will be greater than the cost of increasing the size of the bolster or the dimensions of it, or making the bolster in a more costly form. There is sufficient room for larger truss rods and needle beams, and if the bolster cannot be increased in size, certainly, then other parts can be. If the bolster is made strong enough, it seems at the present time that it will require a design, the cost of repair of which and also the cost of manufacture of which would be much in excess of the present bolster, and it seems doubtful whether it is advisable to go to this extra expense of more costly labor, and, we might say, more costly tools, and a more more elaborate shop in which to do the work.

Then it has been said that the body bolsters cannot be made stiff enough to carry the load if unaided. If this is so, and in the first part of the paper such a position is taken, in a tentative way, it is more necessary to distribute the load to the bolster under the most favorable conditions. It appears that no one has taken the position that the other parts of the framing cannot be manipulated in such a way as to favor the body bolster more than is done at the present time.

MR. WAITT: I would like to say one word in regard to steel cars. On those that I spoke of as having the side bearings in contact, it was claimed by the manufacturers, and I think is truly borne out by the facts, that the sagging was due to weakness in the center plate, and the support directly above the center plate, and not due to general weakness of the body bolster, and that by filling in under the center

plate with the casting, so that the bearing was transmitted through solid metal to the top of the sills, the trouble of sagging will be entirely avoided. The latest designs of steel cars have body bolsters and metal enough and proper distribution so as to make them absolutely rigid under 110,000-pound loads.

THE CHAIRMAN: If there is no further discussion on the paper, we will pass to "Topical Discussions." The first subject is: "On the road with which you are connected, by what improved methods are the ashes handled which are removed from locomotive ash pans?" We have some communications which the Secretary will read, and then the subject will be open for discussion.

HANDLING CINDERS FROM LOCOMOTIVES.

MR. J. G. NEUFFER (B. & O. S.-W. Ry.): For the last five or six years, the B. & O. S.-W. Ry. has been handling ashes with a crane, in operating which the services of three men and an engineer were required. The ashes were dropped from an engine into buckets beneath the tracks, one bucket holding about 5,000 pounds of wet ashes. The buckets were then raised by the crane, an engine furnishing the necessary power. It then required the services of two men to swing the crane around so as to deposit the ashes in the car.

This method has recently been greatly simplified by the introduction of compressed air as a means of raising the buckets and turning the crane. Two cylinders are used, one a single acting cylinder 12 inches in diameter, with a 14-foot stroke, which does the hoisting, and the other a double acting cylinder 8 inches in diameter, with a 4½-foot stroke, which turns the crane. These are shown in Figs. 1 and 2. The hoisting cylinder is anchored to the ground in a horizontal position, so that the hook on the end of its piston rod can be fastened to the chain of the crane. This cylinder receives its air through a ¾-inch pipe and exhausts through two release valves, 1¼ inches in diameter and ¾-inch in diameter respectively. When lowering the bucket, both valves are used until the bucket has acquired a momentum, after which the ¾-inch valve is sufficient to allow the bucket to lower at a suitable speed to enable the operator to locate it in the pit. This cylinder can also be used to place the ash cars along the track when the switch engine is otherwise engaged.

The turning cylinder is placed on an angle, and pivoted at the rear, so as to insure a straight pull on the chain which runs from the end of the piston rod to the disc about the base of the crane. A ¾-inch pipe is also used to supply the cylinder, but in order to give a steady pull is reduced to a 3-16-inch pipe where it enters the cylinder. The device, which has been in operation at the Chillicothe shops of the B. & O. S.-W. for the last three months, has given entire satisfaction. The pressure of the air is sixty-five pounds. The merits of the "air cylinder method" are easily seen, when it is considered that with this device one man now does as much work as three formerly did with the assistance of an engine.

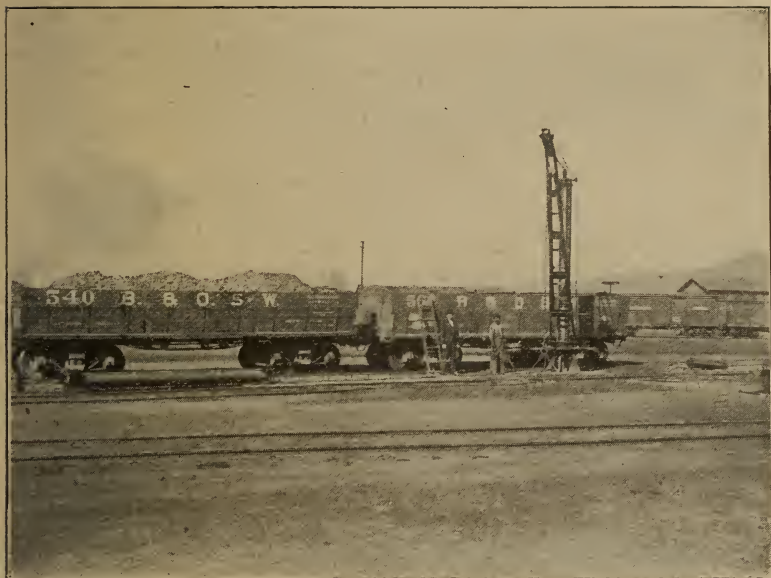


FIG. 1.



FIG. 2.

MR. WM. FORSYTH (Northern Pacific R. R.): I suppose that the subject refers principally to methods of operating clinker pits by machinery, but as an intermediate stage between the old method in which clinkers were handled three or four times before they were finally disposed of, I have to suggest a form of clinker pit and depressed track, shown in Fig. 3, which is so arranged

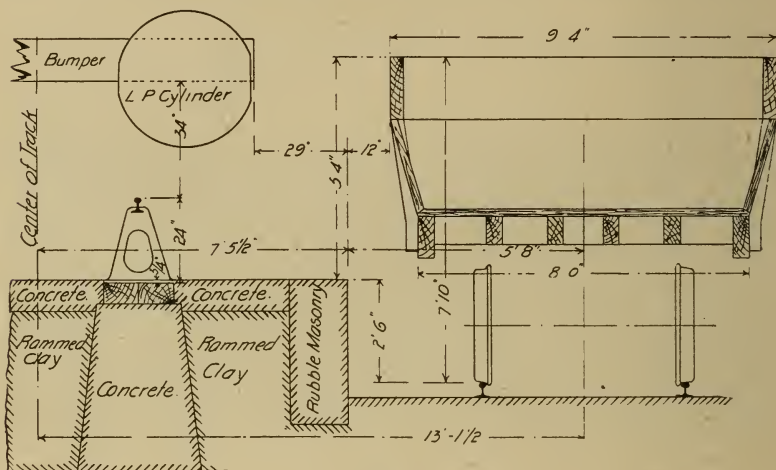


FIG. 3.

that clinkers are handled but once from the pit to the side dump cinder car. I have known this plan to have been worked out successfully, and to have effected considerable saving in the cost of labor for handling clinkers. I present it as a suggestion for an improvement where more expensive methods by means of machinery are not possible.

MR. E. E. RUSSELL TRATMAN: In regard to the use of dump cars for handling cinders, it might not pay to build special cars, except when a road has many points at which large quantities of cinders are handled daily. But many roads have a number of side-dumping ballast and gravel cars, some of which might be set aside for use at cinder pits. This would seem to be the proper plan, from an operating point of view, instead of using for railway service, cars which properly belong to the freight service. A sloping apron along the car would serve to deliver the cinders clear of the rails. A long and interesting report upon cinder pits was presented at the 1894 meeting of the Association of Railway Superintendents of Bridges and Buildings. From this, I have taken the following figures, but it is not safe to make any comparison of the figures, as there is no knowing what items are included or omitted in each case.

Shoveling cinders from depressed closed pit to ash car.—Without depressed ash-car track, 12 cts. per cu. yd. (C., R. & P. Ry.). With depressed track, three gondola cars loaded every 24 hours with 25 cu. yds. per car for \$4.50, or 6 cts. per cu. yd. (P., Ft. W. & C. Ry.).

Shoveling cinders from raised open pits.—With depressed ash-car track, $4\frac{1}{2}$ cts. per cu. yd. (C., N. O. & T. P. Ry.). From pit to car, \$1.00 per car load. (Mo. Pac. Ry.).

Shoveling cinders from depressed open pit.—From pit to car, with partly depressed ash-car track, $7\frac{1}{2}$ cts. per cu. yd. (C., R. I. & P. Ry.). Including loading into cars, 13.5 cts. for ash-pit men, and 7.2 cts. for hostlers, or 20.7 cts. per engine. (P., C., C. & St. L. Ry.). From pit to car, with depressed track, \$1.02 per car. (P., Ft. W. & C. Ry.). From pit to car, without depressed track, \$1.50 per car, or about 5 cts. per cu. yd. (B. & O. R. R.). Cleaning and loading at East Tyrone, 6.86 cts. per cu. yd., averaging 1.25 cu. yds., or 8.58 cts. per engine. (Penn. R. R.).

Handling cinders with bucket and crane.—(B. & O. S.-W. Ry.). The buckets are set under the engine ash-pan, and are emptied into dumpcars, so that no shoveling is required. At Washington, Ind., two men at \$1.20 per day do the work which required six shovelers at the same wages, or for one-third the cost of shoveling. At Cincinnati the cost is 6 cts. per engine, as compared with 12 cts. for shoveling.

Handling by bucket conveyor. At the Wallace St. station, Philadelphia; 8 cts. per ton for cinders and 4 cts. per ton for coal. (Phil. & Read. R. R.).

MR. HILL: We are using depressed tracks along side of the clinker pits and throw the cinders from the pit into drop-side cars standing on these depressed tracks. I am of the opinion that this is as cheap and satisfactory a method as has been devised.

MR. J. N. BARR (C., M. & St. P. Ry.): Mr. Chairman, I do not know whether there is very much to be said on this subject. Of course, there is a possibility of making a very pretty and complicated piece of machinery to handle cinders. I don't know what it would cost; it could be made very complete. We use, where it is a matter of sufficient importance, a depressed track. We carry the track, on which the engine moves, on iron columns and high beams. We have recently placed inclined sheets on one side of the pit that is formed by these columns, so that the cinder, as it is dumped from the ash pan, is thrown out to the side of the track; the men then

handle it with shovels directly from the pile that is formed into the car. In a great many pits the cinders have to be handled twice, that is, shoveled out from under the location of the engine, and afterwards shoveled into a car; we save one shoveling, and that is as far as we have gone. I do not know whether we would be inclined to go much farther than that in any event, as the expenditure and cost of repairs would come in quite decidedly, and play quite an important part in proportion to the expense of shoveling cinders.

MR. G. W. RHODES (C., B. & Q. R. R.): I think that in the last few years there has been great economy, in nearly all the railroad shops, in the matter of the number of handlings of material. There are a few shops now, probably, that do not get their ash-pit cinders into the car with one handling, even around the shops where the ashes from the stationary boilers and from the blacksmith fires are made. A few years ago it was the common practice to dump these cinders with a wheel-barrow outside the shop, and at a subsequent period have some one come along and load them into a car. It is quite a common practice now to have a car located near the shop, at an incline, and a man wheels the ashes up the incline and dumps them into the car. There is one criticism that I would make; we are not as careful about the cars into which the cinders are put as we should be. We are careful in some instances to have one handling in getting the stuff into the car, but it has to be handled out of the car, and why those who have the handling of cinders do not insist on having a car provided that will dump the cinders out, in place of the slow hand shoveling method, is a subject that I think ought to get more attention. I have seen these cinders put in old box cars and old stock cars to be shoveled out by hand.

MR. BARR: In regard to the financial end of this matter; we will say here is a blacksmith shop that fills a car with cinders every two weeks. That would be about twenty-five car loads a year, and if a car is built especially for that purpose, say costing \$500, if built so as to be loaded easily and to be unloaded easily; the interest on that money at 6 per cent. will be \$30.00 a year, and we can get a car loaded and unloaded twenty-five times for pretty nearly \$25.00 a year. So that I believe, if you consider everything, including the deterioration of the car, etc., you will find that you have a loss on the investment.

MR. DELANO: Mr. Chairman, I have looked into this question a

little, and I am inclined to agree with Mr. Barr and one or two of the other speakers, that there is not very much to be made by the use of machinery to load cinders. Of course, almost every roundhouse has its depressed track. I don't know whether all such tracks are put in, in just the same way. Some prefer having one rail of the track supported on iron stand, leaving the clinker pit open on the side toward the cars to be loaded. We do not, in Chicago. We like an ordinary clinker pit, closed on both sides, and having the depressed track about five and a half feet lower than the track on which the engines are clinkered, and close enough, say about ten and a half foot centers, so that the top of the car into which the cinders are being emptied, is very nearly level with the top of the rail of the clinker pit track. The only handling then is simply the one shoveling from the clinker pit directly into the car. With the number of men that there must be about a roundhouse, for various work, it seems to me that this plan is about as economical as possible. As Mr. Barr says, it is possible to figure out all kinds of interesting machinery in the way of conveyors and hoists, but when the interest on the cost of those devices and the constant and rapid deterioration of anything in the shape of iron that comes in contact with cinders are considered, I think that it will be found to be a more expensive method than the method of shoveling direct from the pit into the car.

One point Mr. Rhodes made in regard to side-dumping cars. We find they are very nice in some cases, but there are a great many times when a side-dump car cannot be used, and much less a bottom-dump car. If a trestle is being filled, or anything like that, it doesn't matter how the stuff is let run out, from the bottom or the side, but if the cinders must be distributed on level ground, the trouble with most cars is that a large part of the cinders are dumped on the rail, and after going through the process of dumping, it is necessary to get underneath the car and clear off the track, and for that reason very often we shovel out cars which are provided for side-dumping, simply because we want the cinders off a little more to one side, and we figure that it is cheaper to shovel directly from the car.

MR. DEEMS (C., B. & Q. R. R.): Mr. Chairman, in looking at this photograph and, in fact, having seen the device in operation, the objection which occurred to me was this,—that the length of the clinker pit is very much limited. I know that there are arrangements

of this kind carried on wheels which can be moved along a track parallel with the clinker pit, but on account of not having sufficient room such an arrangement is not practicable in all cases. Now, a short clinker pit is an unmitigated evil at a roundhouse, in very many instances. Engines come in at very short intervals for a while, and a very long clinker pit is needed; it will be filled with cinders as the engines arrive, and then during the hour or two following, when perhaps there are none arriving, the pit may be cleaned out. For that reason, it seems to me, this device would be very objectionable; a depressed track overcomes such objection, and seems to me to fulfill every purpose. But I have seen depressed tracks, such as those of which Mr. Barr speaks, so arranged that the cinders are dropped down and then shoveled off to one side, and then shoveled into a car from a surface which is level with the bottom of the car wheels, and it seems to me that such depressed tracks are not satisfactory. My idea of a depressed track is one such as Mr. Delano has described, where the top of the dump car is very nearly at the top of the rail of the clinker pit proper, so that it is not necessary to elevate the cinders while shoveling, but they can be loaded directly from the clinker pit into the car, with the top of the car about level with the bottom of the clinker pit, and not more than 18 or 20 inches from it.

There is nothing that is so beneficial in busy times as to have a long clinker pit track, that may be filled as occasion requires, and emptied when an opportunity presents.

MR. R. D. SMITH (C., B. & Q. R. R.): Mr. Delano has well described the clinker pit in use on the C., B. & Q. in Chicago, but he did not give the length of the pit. At one of our roundhouses we have a pit about fifty feet long on one side of the house, while on the other side, where we clinker the main line engines, the pit is ninety feet long. A man standing in the pit throws the cinders into a car that stands on a depressed track laid as close as possible to the pit track. The cars are ordinary flat-bottomed cars, with sides thirty-six inches high. There are three doors on each side that are held in position with stakes in ordinary stake pockets, the stakes being hung on chains, so that when they are knocked out they won't be lost off. In ordinary practice the stakes are knocked out and the cinders shoveled from the bottom of the car out on the track where they are needed.

I hoped that in this discussion somebody would give the cost of

loading cinders, as I wish to state what it costs our company, and would like to compare our figures with those obtained by other roads. I do not know how these figures will be received by those who have elaborate schemes for loading cinders with machinery, but when machinery has been proposed for this work I have given the cost of our present practice, and suggested that only a cheaper method would be considered. The track to which I refer was put in use in September, 1893, at which time we loaded two cars of cinders a day. I would say that most of the clinkering is done by the night force, which is so small in number that the cleaning out of the pit is left for the day men, unless the pit becomes full, in which case the night men load some into the cars. Before we used depressed tracks the cinders were shoveled from the pit to a platform, and from the platform into a car, at a cost of \$1.77 per car. After the depressed tracks were put in, and we loaded direct from the pit into the car, we decreased the cost to 97 cents a car, and that is what we are paying to-day for loading cinders. I would like to hear from some of the other members as to what it is costing them for similar work.

THE CHAIRMAN: Can you enlighten us upon that subject, Mr. Luttrell?

MR. LUTTRELL: I have no figures. I would like to ask Mr. Smith the size of the car to which he refers.

MR. SMITH: Each car holds a little more than twenty-six cubic yards. We figure that we get twenty-seven cubic yards in a car, when the cinders are heaped in the center, as they are ordinarily loaded.

MR. WHYTE: Mr. Chairman, the opinion seems to be favorable to depressed tracks on which to use cinder cars, but at old round-houses and stations that were built years ago, there may not be room for the depressed track, and then these special devices may be used to much advantage. It is necessary to have the clinker pit very close to the roundhouse, and it may give considerable trouble, sometimes, to get a depressed track at a place which is already crowded; at such places, then, these special devices for lifting the ashes from the pit to the car are quite necessary.

MR. BARR: I apprehend that no one would think, even the most

ardent advocates of the system, of putting these devices at the little old roundhouses, that are twenty years old. The only places, I presume, for which they are recommended, are at the modern roundhouses, where a great many engines are handled, and where the saving would pay for the permanent investment involved. We have a great many small roundhouses on the road, at which we would not for a moment contemplate the expenditure necessary to have a depressed track, even if we could have one. It would be money thrown away.

DRYING AND HANDLING SAND FOR LOCOMOTIVES.

THE CHAIRMAN: The next subject is: "What improved means are used for drying sand and delivering it to the sand box on the locomotive?" The Secretary has a communication from Mr. H. S. Bryan, of the Duluth & Iron Range R. R., which he will read by way of opening the subject:

MR. H. S. BRYAN (D. & I. R. R.): As I cannot be present at the next meeting of the club on the 15th inst. to take part in the topical discussions, I beg to submit a description of our method of delivering sand to the sand boxes on locomotives, which has been in use here for some time and has so far proved entirely satisfactory.

At present we are drying our sand with the ordinary sand stove, but have commenced the construction of an apparatus for drying it by steam. Our method of delivering it to the sand box on the locomotive is clearly shown in the accompanying illustration, Fig. 4. The apparatus consists of a reservoir of any required capacity; a 2-inch pipe leading from near the bottom of the reservoir to such height as to clear the sand box by a few feet, the upper end of the pipe being bent downward, and to it is attached a short piece of hose. Connected to the top of this reservoir is an air pipe leading outside of the building, and to the other end is attached a hose and air brake coupling. The reservoir having been filled with sand, the air pipe is coupled to the train pipe of the locomotive through which air is admitted to the sand reservoir.

The sand pipe, which leads to the sand box on the locomotive, is fitted with an ordinary stop cock; when it is opened, the pressure of air in the reservoir forces the sand up through the pipe from the reservoir and into the sand box of the locomotive. The greater the air pressure in the reservoir the faster sand will flow through the pipe, but forty to fifty pounds will fill an ordinary sand box in from two to three minutes. If a pressure of seventy to eighty pounds is applied, the second locomotive can be supplied with the reserve pressure without coupling on to the train pipe. The sand pipe should be drained after using, or a greater pressure will be required to start the flow of sand through the pipe than is ordinarily the case. The device is simple, cheap, easily operated and not liable to get out of order.

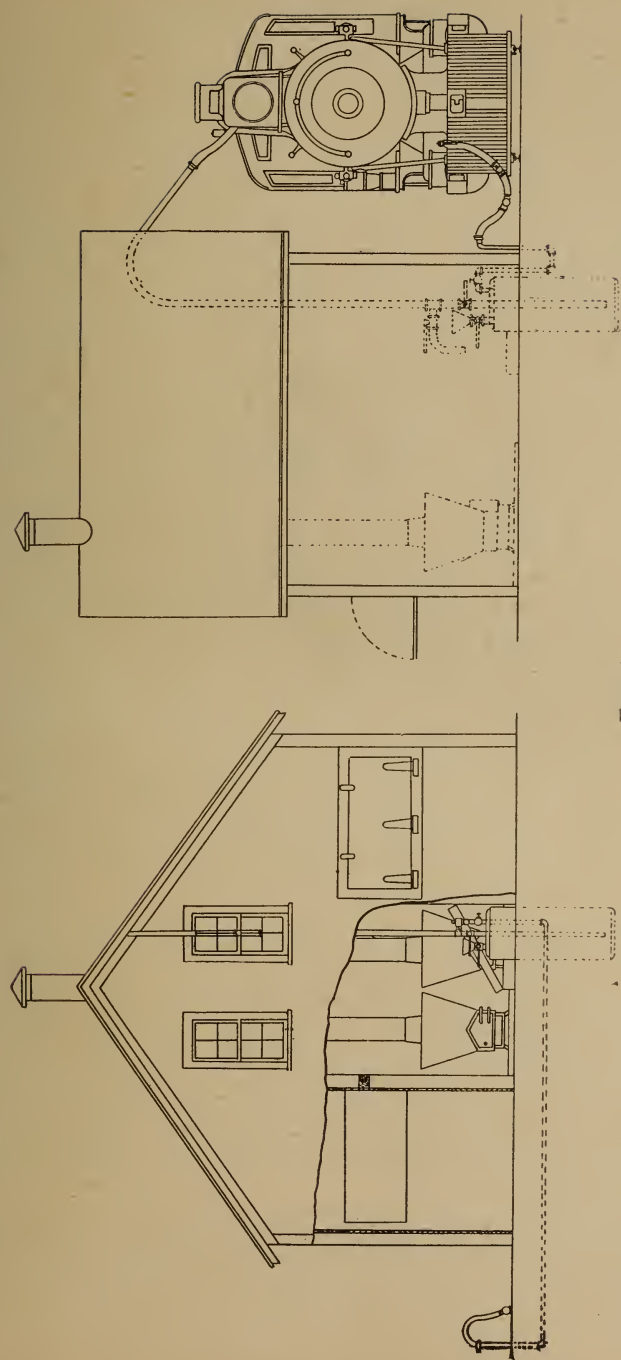


FIG. 4.

MR. JAS. W. HILL (P. & P. U. Ry.): The illustration, Fig. 5, submitted herewith, is a plan which I am using for elevating sand by compressed air. The drum for receiving the sand can be of any desired size, preferably set in a pit in the ground so that sand can be easily delivered into it from the drying apparatus. The hopper has a hinged lid made of netting, and underneath this is another course of netting which is riveted to the hopper to prevent anything getting into the drum when the upper hinged lid is open. The upper lid is hinged for the purpose of quickly and easily throwing off the screenings that accumulate. There is a $1\frac{1}{4}$ -inch pipe projecting through the top of the drum and to within two inches of the bottom; it extends upward about thirty feet to a bin which holds about ten cubic yards of sand. A $\frac{1}{2}$ -inch air pipe is attached to the upper end of the drum and a pressure gauge is attached to it. The method of operating is to fill the drum with sand, close the 4-inch plug cock, shown just above the drum, and turn on the air. The sand is thereupon driven up through the $1\frac{1}{4}$ -inch pipe. When the drum is emptied, the pointer on the gage will indicate it instantly, and the operator closes the air valve. The drum I am using holds about ten cubic feet of sand and we can elevate the sand thirty feet with seventy pounds of air in about forty-five seconds. We find that forty pounds of air pressure will elevate the sand. This shows that it requires one cubic foot of air at forty pounds pressure to elevate one cubic foot of sand to a height of thirty feet. I also use a vent pipe on the top of the drum to let the air out while filling the drum with sand. The vent is not shown in the illustration. I think that this is the cheapest and most satisfactory way of elevating sand.

MR. RHODES: Mr. Chairman, I judge from the illustrations of the device shown with Mr. Bryan's remarks, that it is intended for use where there is no air plant, and therefore they use the air of each locomotive which is receiving sand. We have found it wise, where we have an air plant running only during the day, to have a storage of sand, so that during the day when we are elevating sand we blow up sufficient to last during the night, and we do this at nearly every point, in preference to depending upon the locomotive for air pressure.

I notice, also, in this design, that the sand dryer is made in the old way, of a funnel shape around the stove, with the greater diameter at the top. I think that is not good construction. In drying

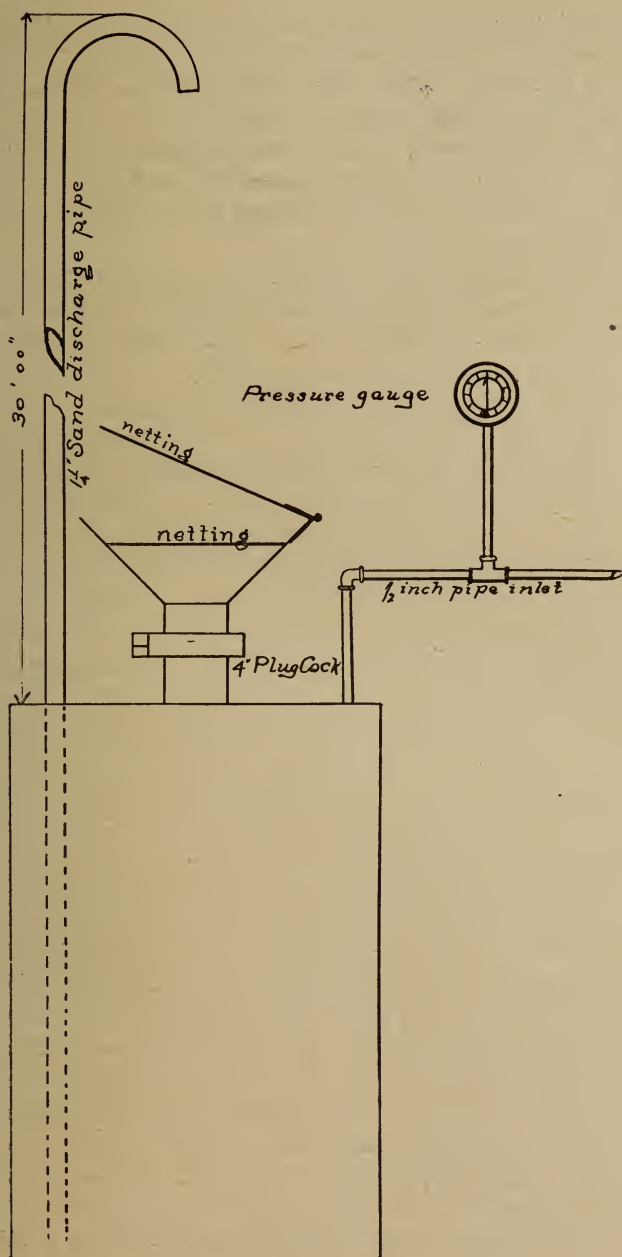


FIG. 5.

the sand with such stoves all the moisture must pass through the sand and escape at the top, because the greater diameter of the sheet-iron case is at the top. The best sand dryers, I believe, are now built with a stove shaped in such a way that the large diameter is at the bottom, and about six inches or ten inches away from the stove a netting is applied; as the heat strikes the sand the moisture readily escapes through the sand and netting to the atmosphere and the sand is dried very quickly.

I believe that, in the way of elevating sand, compressed air can be used to better advantage than anything else, and I am surprised that in some cases, even where air is used largely, its advantages for such purposes are not better appreciated.

MR. HILL: We are using with satisfactory results a large cone-shaped stove, about five feet diameter at the bottom, with netting on the outside of the body of the sand substantially as described by Mr. Rhodes. This dryer was designed in 1880 by Mr. Jacob Johann.

MR. WHYTE: Mr. Chairman, another improvement which can be made on the dryers shown, takes into consideration the relative location of stove, storage bin before elevating, and the elevating reservoir. The stove can be placed on a floor of netting, directly above the bin in which the sand is stored before being elevated, and the reservoir can be placed lower than the bin, so that the sand will fall from the stove through the netting beneath and into the bin, from which it will slide into the reservoir. With such an arrangement gravity and compressed air are the only forces used from the time the sand is placed in the dryer until it is delivered to the locomotive, or until, indeed, it is delivered to the rail in advance of the driving wheels. Both arrangements, shown in the illustrations, indicate that the sand is elevated to a storage bin located almost directly above the dryer, or, rather, that the dryer is located directly under the bin from which the locomotives are immediately supplied; this is not necessary, and if the sand can be dried to better advantage at some distance from the place where the locomotives take sand, the sand may readily be forced by air pressure from the more distant point. The pipe through which the sand is conducted should have as few crooks and bends as possible, and these should be made with as long radii as possible, the sharper bends being made with very thick pipe, to provide longer service. The usual bend of 180 degrees at the delivery end of the pipe can be reduced to a bend of

45 degrees, or less, by directing the current of sand against a plank, from which the sand falls into the storage bin. The usual bend of 180 degrees, necessary to direct the sand downward, is very expensive to maintain, and while the plank, which is suggested for substitution, requires replacing at intervals, the cost for doing so is very small. The cheapest dryer, probably, is to use the rays of the sun. There are places in which the rays of the sun can furnish a very good and reliable means for drying sand, but it is probable that in this locality, were this means used largely, the cost for storage bins and drying space sufficient to insure a supply of dry sand for all conditions of weather, would be greater than the cost of operating stoves.

MR. DEEMS: I will mention something which I saw several times on the Milwaukee road, where they utilized the heat from the front end of the heating boiler, that is, the smoke arch. It was an old locomotive boiler used for heating, and they utilized the heat from the smoke arch to dry the sand, and did it successfully. I thought that it was about the best scheme I had seen for drying sand. Of course it could be used only where the local conditions were suitable.

THE CHAIRMAN: Last week I was south, in Mississippi, and visited a motive power plant where experiments were in progress with a process for drying sand as follows: They had 1,000 feet of 1¼-inch pipe on the floor and were unloading a car load of sand on top of it and expected to dry the sand by radiation. This was an experiment just being tried and I will be glad to let any of the members know the result sometime in the near future.

MR. R. D. SMITH: As we use at Chicago large quantities of sand for engines, a description of our plant may not be out of place. Since receiving the list of subjects for topical discussion, I have been looking up the amount of sand that we used last year, and find that from Oct. 1, 1897, to Oct. 1, 1898, we used, in round figures, 200 cars of sand or 3,916 cubic yards. We try to unload all of our sand through the summer and fall months, closing up our storage shed in the winter months, when sand is frozen and expensive to handle. Our storage shed for holding the sand is on a triangular piece of ground, with the drying room in one corner. The storage shed, which is covered, is built the same as most sheds used for that purpose, except that instead of unloading the sand at the top of the ground, we excavated to a depth of four feet, thinking we could store

sand as well below the ground level as above it. The upper portion of the shed is divided into sections with doors that open inward and upward, so that a car can be run at any place alongside of the shed and unloaded. The sand drying room is a building nineteen feet square and is fitted with two large drying stoves, cone-shaped, with the largest diameter down, the largest diameter being four feet and nine inches. As the sand dries it is screened into a reservoir holding about six cubic feet. The sifted sand falls through an 8-inch opening which is closed by a cover cast with some lips that fit in a race, so that an eighth turn draws it down and makes an air tight joint on the top, and after closing the large opening, air is admitted through a quarter-inch pipe to the top of the sand and in something less than one minute the sand in the reservoir is elevated through an ordinary 2-inch gas pipe, extending from the bottom of the tank upwards about twenty-nine feet, into a bin divided into two compartments. Each compartment is built like a hopper in a mill, having an opening at the bottom that ends in a 4-inch pipe with a rotary valve: There is a spout on the outside of the building, that is pulled down, and the rotary valve is turned to allow the sand to flow to the locomotive sand boxes, the same as water flows from a pipe to an engine tank. We have used different methods of drying and elevating sand, having tried steam dryers, and different air and mechanical elevators, but our present arrangement for drying with the large stoves and elevating by putting the pressure on top of the sand has been the most satisfactory and economical. We find it costs us to unload, dry and sift, $11\frac{1}{2}$ cts. per cubic yard. This cost includes taking the sand from the car, drying, elevating and placing in a bin ready to be put in the sand box of the locomotive.

MR. RHODES: I would like to make one other suggestion. At the entrances to some roundhouses, even where many engines are not served, it will be found that by using a depressed track and assembling the water arrangements and the sanding arrangements at one point, only one attendant is necessary to look after the combination of work. We have been able to make marked economies at several points on our line by this method of concentrating work.

THE CHAIRMAN: Is there anything further to be said? If not, we will declare the discussion closed. You understand that if you have any questions that you want brought up here, send them to the Secretary, and they will be discussed. I hope we will try and

bring in interesting subjects, so that we can have full and interesting meetings. There is no reason why we should not. I want you all to feel that this Club is for each individual member to express his opinion, and we want to hear from the younger members. I noticed three to-day whom I have never heard speak here before. I am glad to see the young men coming in and expressing their opinions. Our President is away to-day, and it became my duty to preside. If there is no further business to come before the meeting, a motion to adjourn will be in order. The motion is carried.

Adjourned.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED, April, 1884.

INCORPORATED, March, 1897

DECEMBER 25, 1898.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 4.

CHICAGO, ILL.

{ \$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Roadmaster, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER. JOHN W. CLOUD.
F. W. BRAZIER. H. G. HETZLER.
PETER H. PECK. F. W. SARGENT
PROF. WM. F. M. GOSS.

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio.

The regular monthly meeting of the Western Railway Club was called to order at 2 p. m. Tuesday, December 20, 1898, in the Auditorium Hotel, Chicago, Ill. President C. A. Schroyer in the chair.

Following are the names of those who registered:

Anderson, Thos.	Hyndman, F. T.	Schroyer, C. A.
Anderson, Geo. T.	Jacoby, W. L.	Scott, G. W.
Brazier, F. W.	Johann, Jacob	Shea, R. T.
Butler, W. W.	Johnson, A. H.	Slater, F.
Canfield, L. T.	Keegan, J. E.	Smart, R. A.
Castle, A. M.	Keeler, Sanford.	Smith, R. D.
Clark, F. H.	Kuhlman, H. V.	Smith, L. L.
Clifford, C. J.	Lawes, T. S.	Smith, Frank P.
Cooke, W. J.	Lencke, J. K.	Smith, J. E.
Crane, Chas. A.	Mabbs, J. W.	Snow, T. W.
Crosman, Walter D.	MacKenzie, John	Stafford, B. E. D.
Cushing, Geo. W.	Maher, P.	Thompson, W. O.
Davies, W. O.	Marshall, W. H.	Thurtell, B. W.
Delano, F. A.	Medway, John	Vissering, Harry
Farmer, G. W.	Miller, Robt.	Waite, A. M.
Fildes, Thos.	Morris, A. D.	Wakeman, C. J.
Gashe, F. G.	Morris, T. R.	Wells, F. C.
Gilleland, D. J.	Murphy, Chris.	Wheeler, John T.
Giroux, Gustave	Neely, B. J.	Whitridge J. C.
Goehrs, Wm. H.	Noble, L. C.	Whyte, F. M.
Gordon, Frank Lee	Parisoe, L.	Wight, S. B.
Goss, Prof. Wm. F. M.	Paxton, Thos.	Widner, J. E.
Grieves, E. W.	Peck, Peter H.	Woods, J. L.
Hatswell, T. J.	Rhodes, G. W.	Woods, E. S.
Hawksworth, D.	Rogers, M. J.	Younglove, T. G.
Hetzler, H. G.	Sanborn, John G.	
Hooper, W. H.	Scales, Richmond P.	

THE PRESIDENT: The first order of business is approving of the minutes of the November meeting; these have been published and are in the hands of all the members. If there are no objections, they will stand approved as printed. Hearing no objections, the minutes are approved.

The report of the Committee on Couplers might properly come under the head of unfinished business, but we will pass that order and move on to the order of Committee Reports and let the committee make a report under that order.

MR. F. A. DELANO (C., B. & Q. R. R.): As chairman of that committee I must say that I am taken a little bit unawares. Copies

of a letter sent out by the committee to prominent coupler and railroad men in this part of the country have been handed around to the members present. In order that that letter may reach not only those who were especially addressed, but also all members of our Club, it has been printed and distributed here, and will also appear in the minutes. The letter follows:

COMMITTEE OF WESTERN RAILWAY CLUB ON M. C. B.
COUPLERS.

F. A. DELANO, Chairman.
J. N. BARR,
T. FILDES,
J. MACKENZIE,
P. H. PECK.

CHICAGO, ILL., Nov. 25, 1898.

DEAR SIR:—The committee appointed by the Chairman of the Western Railway Club to consider the subject of M. C. B. couplers and knuckles, which was discussed at the October meeting of the Club, decided at their latest meeting to ask the various members of the committee, and from any other available sources, for information on certain points connected with this question. In its appointment the committee was not limited within any narrow lines, but simply asked to investigate all phases of the subject which were discussed at the meeting, with a view to making, if possible, some recommendations looking toward the standardizing of the principal dimensions of M. C. B. couplers; securing greater uniformity of parts, and pointing out the weak features of some types of couplers.

The committee offers herewith a tentative list of couplers, classified in three groups, determined by the extent which they are in use. Each group is arranged in alphabetical order. The committee in offering this list does not pretend that it is complete, or that the classification is absolutely correct, and desires that you should offer such suggestions as you think proper for the revision of the list, or reclassification of any of the couplers named therein.

The committee has noticed that there is a considerable difference in the length of guard arm in the M. C. B. couplers. Some manufacturers have reduced guard arm breakages by the simple expedient of shortening it. The effect of this in some cases seems to be that if two couplers with short guard arms are coupled together, they are liable to become uncoupled in service. This suggests the advisability of fixing a standard length of guard arm. We would suggest that it would be valuable information, if in the column of remarks, and especially in the case of the most used couplers, it be noted whether the guard arms may be properly classified as *long* or as *short*, or if this classification seems impossible, whether the length of the guard arm from a given point in the fixed contour line be stated.

Another method of classification suggests itself, unimportant perhaps in the

case of the couplers the least used, but important in the case of those more used, namely: the type of the locking device. If this form of classification strikes you as a good one, the committee requests that you show in the blank column, opposite the coupler, the type of locking device; also, whether there is any attachment added to make the locking positive.

The committee is anxious to obtain information as to the extent to which records of break-in-two's are kept, and investigated by railroads. It is reported to the committee that on a large western road, for a mileage of about 2500 miles, under ordinary conditions of business, there are on an average 18 break-in-two's per day. These break-in-two's are investigated by the superintendent of motive power, and the failure of the M. C. B. couplers, so far as can be ascertained, are taken up with the coupler companies, and with car owners. The committee desires to ascertain to how great an extent records of this kind are kept, and to determine from such records, data as to the frequency of break-in-two's with any given train or car movement.

The favor of an early response is requested by the committee.

Yours truly,

[Signed.] F. A. DELANO, Chairman.

GROUP I.—5000 OR MORE IN USE.

NAME OF COUPLER.	ARE THEY STILL, MANUFACTURED, OR ARE THEY OBSOLETE?	REMARKS.
1 American.....
2 Buckeye.....
3 Chicago.....
4 California.....
5 Gould.....
6 Hien.....
7 Hinson.....
8 Janney.....
9 Little Delaware...
10 Mo. Pacific.....
11 S. H. & H.
12 Standard.....
13 St. Louis.....
14 Smilie.....
15 Trojan.....
16 Tower.....
17 Williams.....

GROUP II.—5000 TO 1000 IN USE.

NAME OF COUPLER.	ARE THEY STILL MANUFACTURED OR ARE THEY OBSOLETE?	REMARKS.
1 Brown.....		
2 Burns.		
3 Barfield.....		
4 Champion.....		
5 Erie.....		
6 Elliott		
7 Foster.....		
8 Forsyth.....		
9 Gallagher.....		
10 Interstate.....		
11 Johnson.....		
12 Lone Star		
13 Ludlow.....		
14 Malten.....		
15 New York.....		
16 Pooley.....		
17 Perfected.....		
18 Peerless		
19 Talbot		
20 Taylor.....		
21 Washburn.....		

GROUP III.—LESS THAN 1,000 IN USE.

NAME OF COUPLER.	ARE THEY STILL MANUFACTURED, OR ARE THEY OBSOLETE?	REMARKS.
1 Ajax.....		
2 Barnes.....		
3 Colwell.....		
4 Columbia.....		
5 Deitz.....		
6 Dowling.....		

GROUP III—Continued.

NAME OF COUPLER.	ARE THEY STILL, MANUFACTURED, OR ARE THEY OBSOLETE?	REMARKS.
7 Drexel.....		
8 Detroit		
9 Diamond.....		
10 Excelsior.....		
11 Edwards.....		
12 Empire.....		
13 Eureka		
14 Fox		
15 Gifford.....		
16 Gelston.....		
17 Imperial.....		
18 Kline		
19 Laburt		
20 Murphy		
21 Price.....		
22 Paragon		
23 Pacific..		
24 Rickison.....		
25 Solid.....		
26 Shomaker		
27 Simplex.....		
28 Springer		
29 Smith		
30 Thurmond		
31 Timms		
32 Union		
33 Vandorsen.....		
34 Walker.....		

I want to say that the committee is only ready at this time to report progress. For the present it is only seeking information, and

has no suggestions to offer, except possibly those made in the letter, to which reference has been made. We have been getting together a mass of valuable information, and the expectation is that this will keep on coming in for several weeks. The committee does not expect to be able to report at the next meeting, and possibly not for two or three meetings, and would like the privilege of more time and the indulgence of the Club. The more we get into the subject, the larger it seems. At the same time your committee does not feel that it is a hopeless subject to "tackle." We may not be able, and have no particular desire, to make a report which shall indicate absolutely what couplers should be used and what couplers discarded. What we want to point out is the directions in which there can be a general improvement; for instance, by indicating certain important specifications and tests. Among the letters which have come in, several have called attention to the fact that the present contour lines do not go sufficiently far and that the M. C. B. gauge should be improved; for example, the gauge should be made so as to refer to the center line of the shaft, or axis of the coupler, because the contour lines of different couplers are found to lie considerably to one side or the other of this central line. One gentleman has sent in a drawing on which he has plotted the contours of five or six couplers, and it shows at a glance how much variation there is between contour lines which are supposedly uniform. The committee would like suggestions and criticisms on the question of classification. It offers in its letter a classification based on use; it does not pretend that this classification is accurate; it is as nearly accurate as we could make it from information we had at hand, and the committee invite criticism from any and all members of the Club; we would like criticism from coupler manufacturers themselves, and I want to add that if any one writing to me wishes not to have his name connected with the information given it will be considered as confidential. There are other methods of classification besides that suggested by the committee; for example, classification by locking devices, classification according to the material used (steel, malleable iron, etc.), or classification by length of guard arm. I think that no one of them can be used exclusively; it would be a good idea to use several systems, in the same way as in the cataloguing of books. There is no attempt now in the best libraries to catalogue books on any one system; several systems are used, and in order to truly comprehend this coupler subject and get

it thoroughly into one's mind, it is important to classify these couplers in a complete manner.

In the letter sent out, the committee has left blank spaces for members to fill in any information that they can give as to whether any of the couplers are already obsolete or going out of use, and any information of this or a similar nature regarding the couplers will be treated confidentially if so requested.

It has been pointed out by one of our members that the M. C. B. coupler is really a piece of machinery and that, like any other piece of machinery, it needs lubrication. On one prominent road the couplers are now lubricated, a very cheap form of lubricant having been obtained for this purpose which has been found to materially assist in the operation of the couplers.

In the letter the committee asks for information as to how many roads, and what roads, are keeping careful, systematic and scientific records of failures of couplers, and I want to dwell a little bit on that subject. Some roads that have equipped themselves with what they consider a good coupler somehow feel that they need not trouble themselves much on the subject, but I wish to point out that every road is interested in every coupler put on the market, for the interchange of equipment makes every road vitally interested in the good points and in the defects of every coupler manufactured.

I will close these informal remarks, and ask some of the other members of the committee who are better equipped than I am to speak on the subject, to supplement what I have probably omitted.

MR. P. H. PECK (C. & W. I. Ry.): I am a member of the committee and it has been suggested to me that the attention of the M. C. B. Association should be called to the question of establishing a standard length of guard arm. That is one of the important parts of the coupler and Mr. Delano has omitted to refer to it; the standard length of guardarm should be considered by the M. C. B. Association.

THE PRESIDENT: There is now a committee of the Master Car Builders' Association appointed to consider the subject and they are to report this present year.

MR. G. W. RHODES (C., B. & Q. R. R.): I am very glad to see the committee make this form of a report and see that they are willing to show their unfinished work, indicating the way they are getting at the work. I think that this coupler question is pretty nearly like the brake question was a few years ago. We got a lot of

brakes in service and we let them run, thinking that they would always work. We afterwards discovered that they needed some sort of attention, and we are now all very busy, I think, making arrangements on our different divisions by which we can properly maintain air brakes. Precisely the same thing is coming up with couplers. We have a lot of couplers in service, but I think I am safe in saying very little attention has been given, to the present time, to their proper maintenance, and what I would like to urge on the owners of the couplers is to stir this matter up themselves, see that their patrons maintain their couplers properly and if they do that they will prevent some of the couplers from getting a name which perhaps would not be desirable. I do not know but that some of these committees, in their reports, ought to propose some form of blank on which to report break-in-twos. A number of roads are keeping reports of break-in-twos but there is no uniformity in the blank used.

Mr. Peck has called attention to the fact that the committee proposes to have a standard length of guard arm, but he did not say why it is regarded an important part of a coupler specification. The reason, I believe, is this: With a short guard arm, which has been so largely introduced lately, perhaps as an outcome of the records of drop tests and broken couplers that have been kept, the manufacturers who have used the short guard arms have shortened the arm too much, and they are sacrificing the wearing life of their coupler from a service standpoint very much by using this short guard arm; I hope that some of the committees will point out the amount of wear that is admissible on a short guard arm and also the amount of wear that is admissible on a long guard arm. On our line, already, when coupler men talk to us about using a coupler new to our line, the first question we ask is, "What is the length of the guard arm on your coupler?" If it comes under the short guard arm class, we do not want it, and the reason we do not want it is, it will not stand the amount of wear that an M. C. B. bar ought to stand. It will not stand as much wear as the long guard arm before it becomes an unsafe coupler and causes break-in-twos.

There is another feature of the draw-bars which I think has not been considered very thoroughly, but which is becoming more and more important as records of break-in-twos are kept. There is, I think, an absolute necessity for some form of positive lock. I believe

that no gravity lock will be regarded, after we have more experience, as a safe form of lock on M. C. B. couplers; I think there will be a demand for an absolutely positive lock. Just what shape that will take I am not prepared to say, but I believe that as soon as we know of the number of break-in-twos we are having, incident to locks coming open in service, the railroads will not buy couplers which do not have positive locks.

MR. JOHN MACKENZIE (N. Y. C. & St. L. Ry.): I am much like the schoolboy in Buffalo who was the subject of a story: There was a heavy snow storm and he was late in getting to school and the school master asked him how he got there; he replied that he had walked backwards all the way. Now, that is the case with me. I have some figures on what we are going to do in regard to this report. You will remember some remarks I made at the last meeting, to the effect that we were to select the best coupler and let the others take care of themselves. We propose to select what couplers to use and we propose to find the failures in per cent. of the number of couplers used, endeavoring to show in that way which coupler is the best to use. I believe this committee has got work on its hands which cannot be accomplished for many a weary day. The idea of this committee undertaking to say what lines we shall follow in M. C. B. couplers or, in other words, the Western Railway Club saying to the committee what lines they shall follow in recommending to the Club the lines of the Master Car Builders' couplers, I think is a weary one—something I think we may not be able to grasp. Somebody has said, and very nicely said, that if the railroad management could get a coupler for fifty cents less than the cost of other couplers, that is the coupler they want to have, irrespective of what the lines or the material may be. I think that the Club ought to bear with this committee very leniently and give them plenty of time. We may be able to bring out something after awhile.

THE PRESIDENT: I think that when this committee was appointed, it was the intention to give them all the necessary time to make this report, and inasmuch as they are reporting progress today, I think we should be satisfied with what they have done. If there is nothing more to be said on the subject, we will proceed with the regular order of business which is the reading of names of those who have applied for membership and whose applications were acted upon.

favorably by the Directors this forenoon. The Secretary then read the following names:

Mr. F. J. Allen, Roadmaster, C., B. & Q. R. R., Aurora, Ill.

Mr. R. L. Ettenger, Mechanical Engineer, C., C. & St. L. Ry., Indianapolis, Ind.

Mr. Robt. P. Lamont, Mgr., Simplex Railway Appliance Co., Chicago.

Mr. Geo. E. Van Brunt, Master Mechanic, Pa. & Northwestern, Bellewood, Pa.

Mr. Henry H. Vaughan, Mechanical Engineer, Q. & C. Co., Chicago.

Mr F. C. Willis, Railroad Supplies, 317, 225 Dearborn St., Chicago.

THE PRESIDENT: We will now consider communications, and the Secretary will read one received from Mr. J. N. Barr:

WEST MILWAUKEE, December 12, 1898.

F. M. WHYTE, Secretary.

Dear Sir:—I send you a copy of communication from the Joint Car Inspection Association at South Omaha with reference to handling cars at interchange points, which do not conform to the Interstate Commerce Commission's requirements as to height of draw-bars.

I think this matter is of sufficient importance to present to the attention of the Western Railway Club.

Yours truly,

J. N. BARR, Supt. Motive Power.

ST. LOUIS, MO., November 22, 1898.

SEC'Y J. C. I. ASS'N.

Dear Sir:—At a meeting of the Joint Car Inspection Association of St. Louis and East St. Louis, held this date, we were instructed to communicate with each Joint Association in the United States and ascertain if the other Joint Associations would join this Association and make request as one body on the Master Car Builders' Association, to place the following before the Interstate Commerce Commission with the view of having said Commission make railway companies not subject to fine on high and low draw-bars, under the following conditions:

First: A car delivered in interchange by one railroad company to another railroad company with draw-bars not in conformity with the Interstate law, the receiving line be allowed to handle such car to its repair track at point of interchange, for the purpose of adjusting draw-bars to conform to the Interstate law, without prejudice against such receiving railroad company for moving car.

Second: A car delivered in interchange by one railroad company to another railroad company with draw-bars not in conformity with the Interstate law, the receiving railroad company be permitted to handle car to its transfer track at point of interchange for the purpose of transferring contents of car and return such car when empty, to point of interchange, without prejudice against such railroad company for so moving car.

Also request that the Interstate Inspector be required by the Interstate Commerce Commission, to not report cars high or low, found in any railroad.

company's yards until Inspector is thoroughly satisfied that track on which such high or low car is standing, is in proper line.

Will you kindly present this paper to your Association at the earliest possible time and return us an answer?

Yours truly,

ED. SWINEFORD, Secy.

THE PRESIDENT: What is your pleasure, gentlemen, regarding this communication? The Chair will entertain a motion to receive the communication and have it printed in the Proceedings and discussed at the next meeting.

MR. RHODES: I make a motion to that effect, Mr. Chairman, that we receive the communication and have it published in our Proceedings and discussed at our next meeting.

The foregoing motion was then put to vote and carried.

THE PRESIDENT: The Secretary will read a communication received from the Niles Tool Works Company:

CHICAGO, Dec. 19, 1898.

F. M. WHYTE, Secretary.

Dear Sir:—We desire to invite the Western Railway Club to accompany a party of railway officials on a trip to inspect our works at Hamilton, Ohio, leaving Tuesday, the 17th day of January, 1899, and returning on the 18th.

We have arranged this date, thinking it would suit the members of the Western Railway Club, as it occurs on the evening of the January meeting, being the third Tuesday of the month.

We think this trip would be of great interest to the Club, and that its members would find it to their advantage to visit our strictly modern shop, where the most improved designs of machine tools may be seen in all stages of construction.

The trip will take but one day, as we leave on Tuesday night and are back in Chicago on Thursday morning.

We will arrange for special sleeping cars for all, and transportation for those who are not provided with passes.

Will you kindly place this before the Club at its meeting on Tuesday, and extend to them, in our name, an invitation to accompany us on the above trip.

We should like to have acceptances at as early a date as convenient, so that we can make all necessary arrangements.

Thanking you in advance for your compliance with our request, we are, with kindest regards.

Yours truly,

THE NILES TOOL WORKS CO.

GEO. F. MILLS, Manager Chicago Office.

MR. PECK: I move that the Club accept the invitation so kindly extended, and that the Secretary be instructed to tender to the Niles Tool Works Company the thanks of the Club for the opportunity presented; and that the Secretary co-operate with the company, to

such extent as may be possible, in arranging for the trip and in ascertaining the names of those who will be the guests of the company on that day.

The motion was seconded and carried.

PRESIDENT SCHROYER: The Secretary will be so instructed.

The President then announced the paper to be read at this meeting was one by Mr. William Garstang, superintendent of motive power of the C., C., C. & St. L. Ry., and entitled "Tests of Coal for Locomotives," and was as follows:

TESTS OF COAL FOR LOCOMOTIVES.

BY MR. WM. GARSTANG.

This Club having honored me with a request for a report on fuel, based on results obtained by this Company and Purdue University in their test last spring of the fuel used by the Big Four Co., I take pleasure in giving you the mode of procedure and the results obtained.

Both the Purdue and the road tests were made under conditions approaching as nearly to the average daily practice as possible, and not with the view of favoring either coal or engine. The tests were conducted on the assumption that the value of any coal for locomotive use may be measured by the number of pounds of water which can be evaporated for each pound of coal burned. It will be seen that this is a correct basis, since the sole purpose of burning coal in a locomotive is that steam may be generated. Now, as the rapidity with which fuel is burned varies greatly with the different conditions of running, and the amount of water evaporated varies with each of these changes, it is necessary, in making an average, to submit all of the different kinds of coal to be tested to several different conditions and each different kind to the same conditions.

The coal under test was from different mines and will be known in this report as A, B, C., etc. Five cars were sent to Purdue University; I give you in part report of Prof. Goss as follows:

"While interest in the tests centers in the evaporation obtained, observations were also made to show the behavior of the fuel with reference to spark losses, the amount of refuse lodging in the ash pan, the draft necessary to maintain a given rate of combustion, the relative amount of smoke produced, the ease with which it may be fired, and such other minor facts as would necessarily suggest themselves; the purpose being to determine as completely as possible the relative behavior of the several samples submitted.

Five samples were submitted which, in the correspondence between your office and this, have been designated as A, B, C, D, and E. Each sample made up a car load lot, the cars were switched to the laboratory, and the coal was, in every case, delivered from the car to the fireman as needed, and at a single handling.

A complete description of the apparatus employed and the methods followed in making the tests, together with a comprehensive record of observed

and calculated results, will be found in the several appendices attached. A summary of these appendices constitutes the body of this report and is as follows:

EVAPORATION.—Locomotive boilers in service are worked within such limits of power that each hour an amount of water is evaporated for each foot of heating surface, which falls between the limits of 4 and 11 pounds. For example, a boiler having 2,000 feet of heating surface may evaporate 10,000 pounds of water per hour, in which case the rate of evaporation is said to be 5, since this is the number of pounds of water evaporated for each foot of heating surface per hour. Again, if the same boiler is called upon to deliver 18,000 pounds of steam per hour, the rate of evaporation becomes 9. Other things

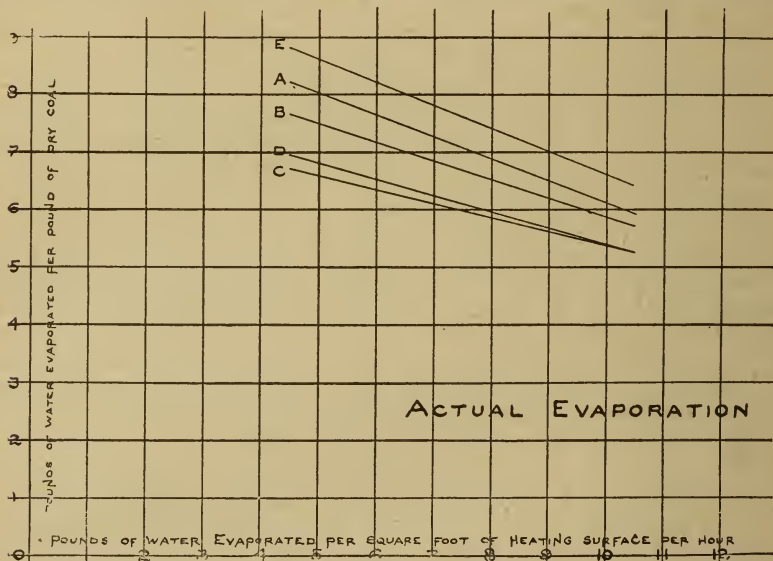


FIG. 1.

being equal, the amount of water evaporated per pound of coal depends upon the rate of evaporation and is greatest when the rate of evaporation is least.

The relationship between rate of evaporation and evaporation per pound of coal for each of the five samples tested is disclosed by Fig. 1.

In explanation of Figure 1, it should be said that the lines given show actual evaporation under the conditions of the tests; that is, under a steam pressure of, approximately, 180 pounds, and an average temperature of feed of about 56° F. It should be stated, also, that the results are entirely comparable, the variations in pressure and in temperature being too slight to change the relative values to any measurable extent.

A comparison of the evaporative efficiency of the several samples, first, when the rate of evaporation per foot of heating surface per hour is 5 pounds, and, second when it is 10 pounds of water, respectively, is given in Table I.

TABLE I.
ACTUAL EVAPORATION.

(The values in this table are based on diagrams, Figs. 3 and 4.)

Designation of sample.	Pounds of water evaporated per pound of coal.		Relative value of sample, calling the value of sample E, one hundred.	
	When the rate of evaporation is 5.	When the rate of evaporation is 10.	For use under light power.	For use under heavy power.
I.	II.	III.	IV.	V.
E.	8.61	6.61	100.	100. = 15 350
A.	8.00	6.13	93.	93. = 14 150
B.	7.49	5.87	87.	89. = 13 150
D.	6.81	5.40	79.	82. = 12 150
C.	6.60	5.37	77.	81. = 12 450

Before these tests were undertaken it was thought likely that the character of the exhaust action would have a material influence on the evaporative efficiency of the boiler. It was for this reason that in the series of tests, as outlined, provision was made for running at a comparatively slow speed with a heavy exhaust, and also at a high speed with a lighter exhaust. The results show that for two of the samples the slow heavy exhaust gave an evaporation

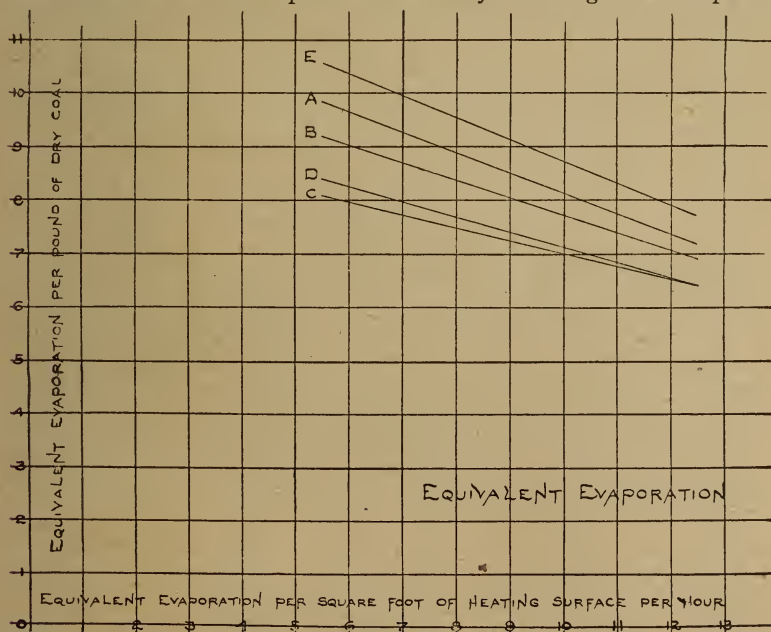


FIG. 2.

which relatively was slightly higher than that given by the quick lighter exhaust action, while in the tests of the remaining three samples, the conditions are reversed. In all cases the differences are so small as to make it quite likely that they arise from causes quite apart from the exhaust action.

The conclusion is, that within the limits of the conditions chosen, there is no measurable difference in evaporative efficiency due to the character of the exhaust blast. If, in each case, the boiler is forced to the same power, the same degree of efficiency results.

EQUIVALENT EVAPORATION.—In reporting data for tests similar to those under consideration, it is customary to reduce the water actually evaporated per pound of coal, to an equivalent weight which would have resulted had the temperature of the feed been constant at 212° F., and the pressure of steam been that of the atmosphere. The "equivalent evaporation" constitutes a logical basis from which to compare the performance of all boilers, even though the steam pressure, or feed-water temperature, or both of these, may vary greatly in different tests. In order that the results of the tests herein described may be readily compared with the results of other boiler tests, the actual evaporation has been reduced to the equivalent evaporation, with the results which are shown in Fig. 2.

SPARKS.—For every test, a record of the weight of cinders entrapped in the front end was determined. Observations were also made to determine the weight of sparks passing out of the stack, but as it was impossible to entrap the entire stream issuing from the stack at any given instant, values obtained in this part of the work should be considered approximately only. The sum of the sparks caught in the front end and of those estimated to have passed out of the stack are, in the following paragraphs, considered together as constituting the spark losses. Values of the spark losses for each of the several samples of coal tested, expressed as a percentage of the weight of coal fired, are presented in Columns II and III of the table below.

TABLE II.
SPARK LOSSES.

(The values in this table are based on diagrams, Figs. 5, 6, 7, 8 and 9.)

Designation of sample.	Percentage of weight of coal fired accounted for as sparks entrapped in front end and passing out of the stack.		Relative weight of sparks pro- duced by each of the several samples in generating the same weight of steam, assuming the weight of sparks resulting from sample E to equal one hundred.	
	When the rate of evaporation is 5.	When the rate of evaporation is 10.	When the rate of evaporation is 5.	When the rate of evaporation is 10
I.	II.	III.	IV.	V.
A.	6.6	21.2	100	100
E.	6.2	15.6	101	79
B.	4.8	16.4	84	87
D.	5.7	17.4	109	100
C.	3.3	13.8	65	80

The results show that when the boiler was worked under conditions which gave an evaporation of 5 pounds of water per foot of heating surface per hour, 6.6 per cent. of sample E was lost in the form of sparks, also that 6.2 per cent. of sample A was lost from the same cause, and so on. When the rate of evaporation was 10, the losses by sparks amounted to 21.2 per cent. and 15.6 per cent. of samples E and A respectively.

The extent of the spark losses disclosed by the preceding table can not fail to surprise one who has not followed the work previously done at Purdue. It is significant that under conditions of running, common to practical service, that from 14 to 21 per cent. of the coal fired disappeared in the form of sparks. (Col. III.) It is true, however, that the *fuel* lost is not so great as this, since the sparks represent fuel which has been partially consumed. The sparks resulting from samples under consideration have not been analyzed, but investigations already made at Purdue indicate that they have from 60 to 75 per cent. of the fuel value of the coal. It will be safe, therefore, to reduce the values given in Cols. II and III by about 25 per cent. in making an estimate of the *fuel* losses resulting from the passage of sparks through the tubes.

It is significant that, with one exception, those samples giving the highest evaporation also give the largest spark losses. Two conditions probably account for this fact. First, the purer coals have a lighter specific gravity, and hence, respond to the draft action more easily than coals intermixed with non-combustible matter; secondly, in general, the purer the coal the lighter the ash, a large percentage of which, instead of falling through the grate, passes out with the sparks and adds its mass to their weight.

It may be urged as an objection to these coals giving high efficiency, that their use is attended by a large spark loss. The argument, while good, is not true to the extent indicated by the values in Cols. II and III. For example, Col. III shows the percentage of the coal fired, accounted for as sparks, but a pound of sample C, producing 0.138 pounds of sparks, did not make as much steam as a pound of sample E, producing 0.212 pounds of sparks. The relative spark producing qualities of the several samples, based *upon the weight of steam generated*, are given in Cols. IV and V. These values, therefore, serve as a logical basis from which to determine the relative spark producing qualities of the several samples.

REFUSE CAUGHT IN ASH-PAN.—Table III shows the percentage of the weight of coal fired which is accounted for as refuse in the ash-pan.

The table shows that when the rate of evaporation is 5, 11.0 per cent. of sample E is accounted for as ash in the ash-pan, while 14.4 per cent. of sample C is accounted for in the same way. When the rate of evaporation is 10, a smaller amount is accounted for as ash, that for E being only 4.9 per cent., while that for C is 11.0.

It is important in this connection to note that the refuse caught in the ash-pan of a locomotive does not represent the entire non-combustible portion of the fuel, for under the heavy draft of a locomotive much non-combustible material passes out through the tubes. Such portions of the non-combustible mix with the sparks, and are, in the present work, accounted for as such.

TABLE III.

REFUSE IN ASH-PAN.

(The values in this table are based on diagrams, Figs. 5, 6, 7, 8 and 9.)

Designation of sample.	Percentage of weight of coal fired, accounted for as refuse in ash-pan.		Relative weight of ash resulting from different samples when the same weight of steam is generated, calling the weight resulting from sample E, one hundred.	
	When the rate of evaporation is 5.	When the rate of evaporation is 10.	When the rate of evaporation is 5.	When the rate of evaporation is 10.
I.	II.	III.	IV.	V.
E.	11.0	4.9	100	100
A.	10.7	9.2	105	203
B.	13.9	11.6	146	267
D.	14.8	10.3	170	257
C.	14.4	11.0	171	276

The amount of refuse caught in the ash-pan, however, constitutes a factor of some importance in any consideration of the relative merits of the different fuels, since all such materials must be carried over the road and handled at terminals, or, if its amount becomes excessive, it must be handled at intermediate points.

By reference to the table it will be seen that when the engine is run at light power, the five samples give very nearly the same amount of refuse in the ash-pan. When the rate of evaporation is 10, however, sample C gives nearly three times as much deposit in the ash-pan as sample E.

In general, it may be said that the better the fuel the less deposit there will be in the ash-pan.

It is clear, from the statements already made, that a very intimate relation exists between the amount of coal accounted for as refuse in the ash-pan and that accounted for in the form of sparks. If, for example, the values of Col. II, Table II, be added to those in Col. II, Table III, the result is practically the same for each of the several samples of coal, and if the values of Col. III of the same tables be added, they also become nearly a constant for all of the several samples of coal. The conclusion is that as the character of the coal changes with reference to refuse, an inverse change results with reference to spark losses. Such a result is logical and is quite in accord with the explanation given with reference to conditions affecting spark losses.

It is evident that the percentage of refuse caught in the ash-pan, given in Cols. II and III of Table III, do not represent the relative amount of ash for the different samples when the same work is to be done, for the reason that a pound of sample C will not yield the same amount of steam as a pound of sample E. The refuse which will result from each of the samples in producing the same amount of steam, as compared with that resulting from sample E, is given

in Cols. III and IV. These columns, especially Col. IV, emphasize the ash producing qualities of the poorer coals.

The clinker in the refuse of the several samples is given by Table IV.

TABLE IV.
CLINKER.

Designation of sample.	Percentage of dry coal accounted for as clinker in ash.
I.	II.
E.	0.6
A.	2.1
B.	4.8
D.	2.3
C.	5.3

DRAFT.—The draft which promotes combustion in a locomotive is produced at the expense of back pressure on the engine. For this reason, a free burning coal will, other things being equal, contribute to the efficiency of the locomotive as a whole, since by its use the cylinders are allowed to do their work under conditions more favorable to economy.

A comparison of the draft necessary to maintain the combustion of the several samples tested is given in Table V.

TABLE V.
DRAFT.

(The values in this table are based on diagrams, Figs. 10 and 11.)

Designation of sample.	Draft in inches of water.	
	Necessary to secure the evaporation of 5 pounds of water per foot of heat- ing surface per hour.	Necessary to secure the evaporation of 10 pounds of water per foot of heat- ing surface per hour.
I.	II.	III.
E.	2.02	5.58
A.	2.12	6.08
B.	2.26	6.02
D.	2.30	6.26
C.	2.12	5.96

The results show that the samples A, B, and C require substantially the same draft for their combustion; that sample D requires a slightly greater draft than the three first mentioned, and that sample E requires a draft which is lower by about 10 per cent. The degree of uniformity disclosed by these results is really quite remarkable and the general conclusion to be derived from them is that, except in the case of E which has some slight advantage, all stand practically upon the same footing.

SMOKE.—Coals A and E are the only coals that show any unusual smoke effects. The smoke produced by coal A is very black and does not clear in the intervals between firing, when the rate of combustion is as great as in the 30 or 50 mile tests. The coal E, on the other hand, does not produce sufficient smoke to color the exhaust for an interval of more than five seconds after it is shoveled into the furnace. During the firing there is a single puff of smoke each time the door is opened, and immediately after the exhaust clears. Coals B, C, and D are nearly equal in their smoke-producing properties. They make enough brown smoke to color the exhaust continuously on a hard run, but but when the firing is light the discharge from the stack clears in the intervals between firing.

EASE IN FIRING.—The labor of firing is, in general, increased by conditions requiring the use of the hook. The necessity for this arises when a coal cokes readily or when it clinkers.

Sample E which gives the highest evaporative efficiency, the least ash, and requires the least draft for its combustion, cokes as soon as fired, and for this reason it is handled at the expense of more labor than either of the other samples. It is possible that in service on the road the tendency to shirk this labor may lead to unevenness in firing which will necessarily result in a lower efficiency for this coal than has been attained in the laboratory, where careful attention was at all times given to the firing.

None of the coals tested gave so much clinker as to require the frequent use of the hook.

No final conclusions should be drawn which do not take into account the relative cost of the several samples, a factor which is unknown to the undersigned. It is evident, however, that no one sample can be said to be the best in every respect. For example, the relative desirability of the several samples, with reference to evaporation, freedom from spark losses, absence of objectionable accumulation in ash-pan and the lightness of draft necessary to promote its combustion is as follows:

TABLE VI.

Designation of sample.	Evaporation.	Freedom from spark losses.	Absence of accumulation in ash-pan.	Lightness of draft.
E.	1st.	4th.	1st.	1st.
A.	2nd.	1st.	2nd.	4th.
B.	3d.	3d.	4th.	3d.
D.	4th.	4th.	3d.	5th.
C.	5th.	2nd.	5th.	2nd.

The four factors by which it is sought, in the preceding tabulation, to judge the value of the several samples do not stand on an equality. It is evident that a high evaporation is more to be desired than lightness of draft, but the facts disclosed are instructive nevertheless. They show that sample E which excels in evaporation, shares with D the doubtful honor of being the largest spark producer.

Also, that sample C, which gives the lowest evaporative efficiency, is second in its freedom from sparks and in lightness of draft.

Reviewing the data with reference to D and C, it will be seen that while D gives an evaporation which is slightly higher than that given by C, in all other respects the latter excels, and doubtless for most purposes C is a more desirable coal than D.

But the significance of all the factors, excepting evaporation, will doubtless need to be considered in connection with the demands for a given service.

PURDUE UNIVERSITY, July 26th, 1898.

ROAD TEST (C., C., C. & St. L. Ry. Co.)—The road test was made with a new simple consolidation engine, and every care was taken to have conditions as nearly alike as possible in all tests. The results are given in Table VII. Care was given to the weighing of coal and water, also to the weight of cars comprising the train; for this purpose there was a man in constant attendance, and all fuel and cinder weights were made on a small scale that had been tested for accuracy, and it is remarkable how nearly the results compare with those obtained in the laboratory at Purdue, making the comparison on their report for similar service which they designate as a "freight run with heavy exhaust."

There were four runs made with each kind of coal, the tests being made between Indianapolis and Cincinnati, a distance of 107 miles, with a maximum grade, west bound, of 83 feet per mile, and east bound 47 feet per mile, except a short pull of 68 feet per mile. The load east was as nearly 1,450 tons, exclusive of engine and tender, as could be readily gotten together and the load west 800 tons.

I will remark, in this connection, that the Big Four Company ordinarily use a pusher on the heavy grade coming west; the regular train for the engine making this test is 1,450 tons, but to avoid any possibility of one kind of coal being favored more than another by the unequal performance of the pushing engine, and the test being strictly a coal test, the load going west was reduced to what the engine alone would haul over all grades at all times, regardless of weather or unfavorable conditions.

We found the conditions regarding the ease of firing, amount of ash and clinker to take care of, ability to maintain a maximum steam pressure, and general satisfaction amongst the enginemen compared in every respect with the findings made at Purdue University, and I will not enlarge on the remarks of Prof. Goss, but will refer you to the attached table, which gives all the information that will likely be of interest, in a more compact form and more readily comparable than I could otherwise present it.

The problems are difficult to determine, as you will note by the table that the coal that gives the greatest efficiency has the greatest evaporative value, maintains the maximum steam pressure, has the smallest percentage of ash, the least smoke and practically no clinker, requires the smallest load to be carried on the tank, consequently handled not only by the firemen, but by the men at coal chutes and ash pit as well, without reference to the fewer number of cars required in this service and costs the most per ton. When compared with the cheapest fuel tested, which has the disadvantage of being a poor steamer, has

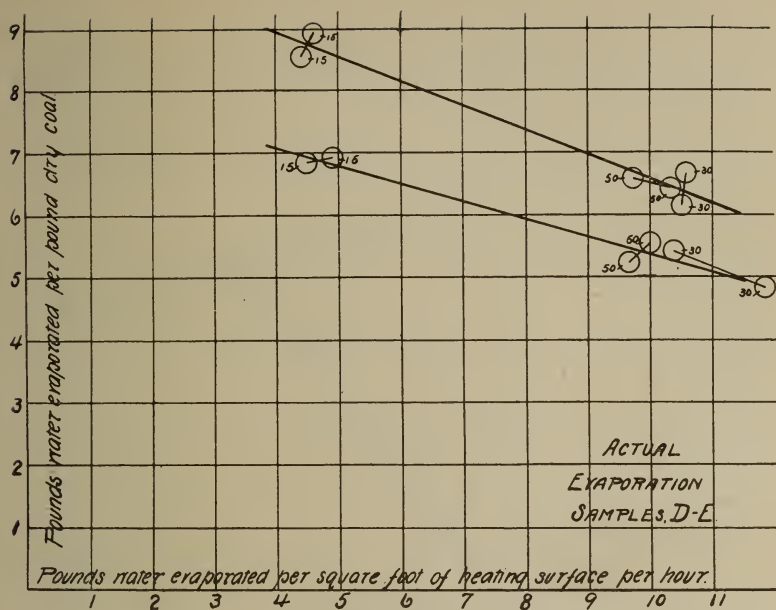


FIG. 4.

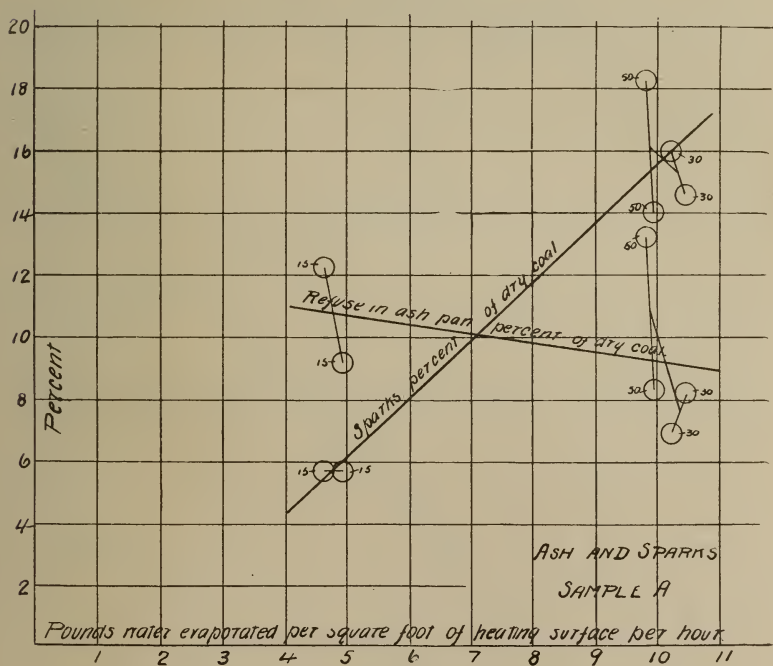


FIG. 5.

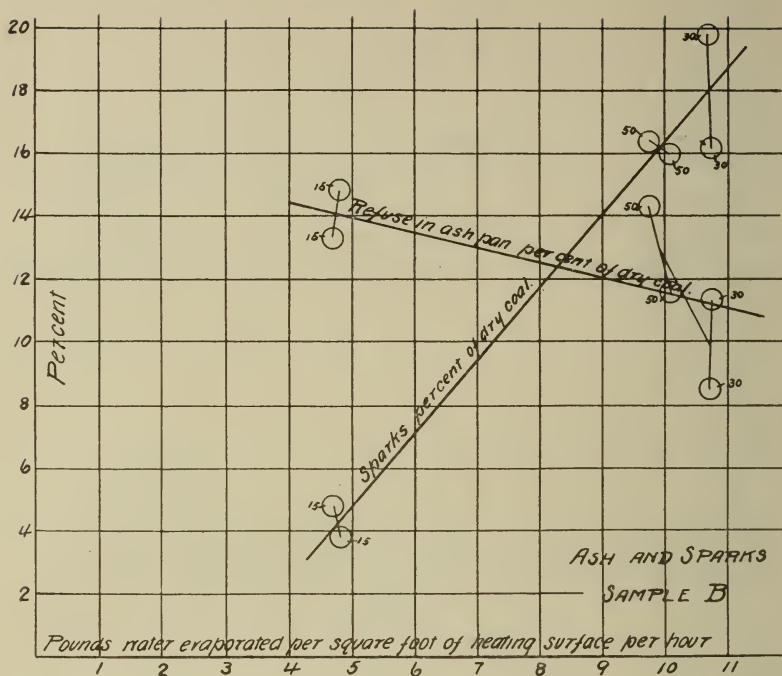


FIG. 6.

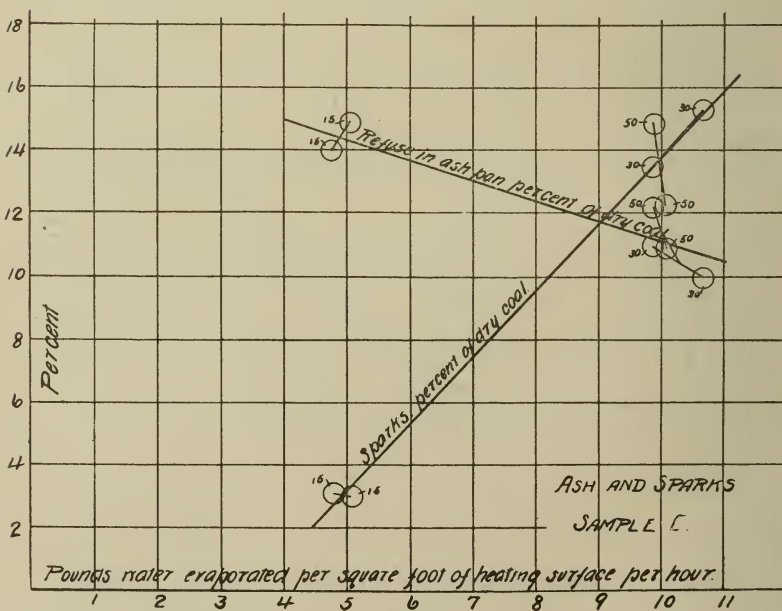


FIG. 7.

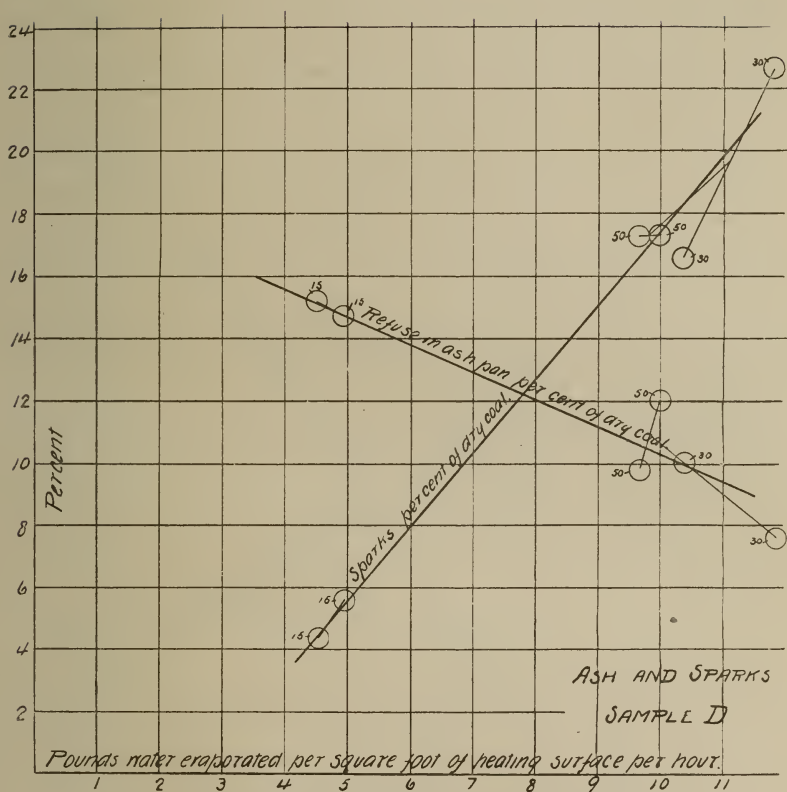


FIG. 8.

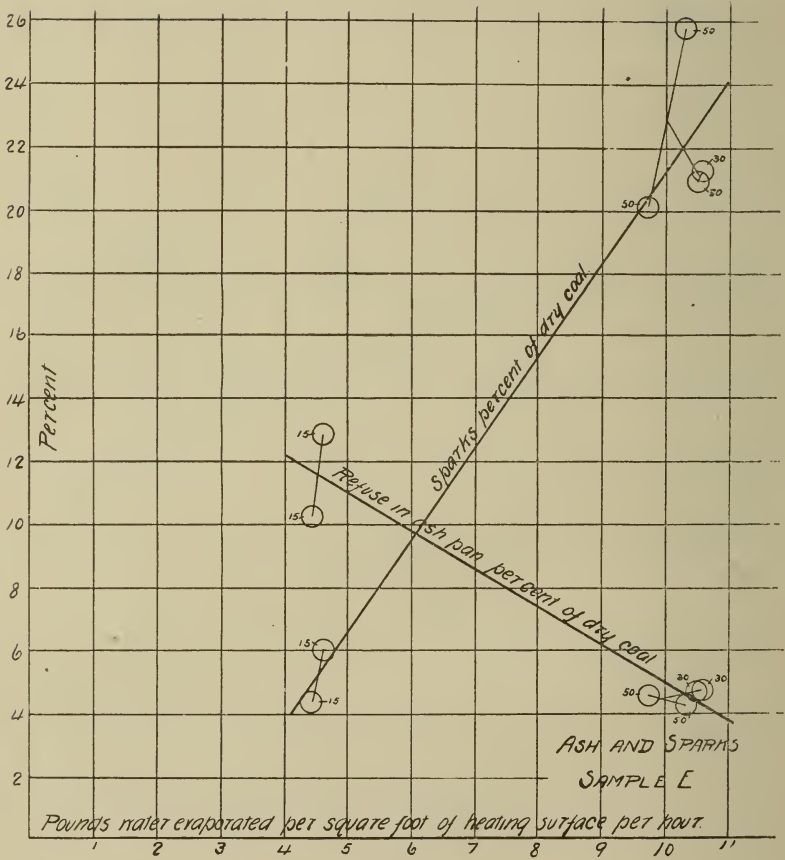


FIG. 9.

WEST-BOUND TRAINS					
	Trip 2	Trip 4	Trip 6	Trip 8	Trip 10
Train Number and Date.....	95. 5-2-98	95. 5-4-98	95. 5-6-98	95. 5-8-98	95. 5-10-98
Run between.....	Riverside and Indianap.	Same	Same	Same	Same
Distance in Miles.....					
Leaving Time.....	9.45 a.m.	9.50 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.
Arriving Time.....	3.50 p.m.	4.50 p.m.	5.10 p.m.	3.30 p.m.	5.10 p.m.
Delayed Time—"Stops"—Hours and Minutes.....	1-15	1-33	2-32	0-50	1-52
Actual Running Time—Hours and Minutes.....	4-50	5-27	4-53	4-55	5-33
Cars—Number Loaded in Train.....	29	33	29	23	25
Cars—Number Empty in Train.....	0	0	0	2	0
Cars—Total Gross Weight of Train in Tons, 2,000 lbs.....	806	826	827	808	804
Coal—Total Used, in Pounds.....	12811	12481	15540	15470	13116
Water—Total Used, in Pounds.....	80782	86866	89570	83148	79092
Average Boiler Gauge Pressure.....	185	185	178	185	178
Rate of Evaporation—Pounds of Water per Pound Coal.....	6.305	6.959	5.120	5.763	6.030
Coal Used—Pounds per Ton Mile.....	.1528	.1451	.1806	.1840	.1568
Total Ton Miles Made.....	83824	85904	86008	84032	83616
Weight of Ash and Clinker—Pounds.....	925	825	1255	1339	1265
Initial and Number of Car that Coal was taken from.....	C. & O. 13199	C. & O. 14097	C.S. & H. 6083	C.S. & H. 6083	C.L. & W. 3080

RECAPITULATION GENERAL AVERAGES—ALL RUNS				
Coal—Pounds Used in Hauling 1,000 Tons, One Mile. Engine 700.....	118.075	148.725	1	
Water—Pounds Evaporated per Pound Coal. Engine 700.....	6.504	5.364		
Water—Pounds Evaporated per Pound Coal. Purdue University.....	5.9	5.1		
Water—Pounds Evaporated per Pound Coal. Calorimeter Test.....	14.206	13.414		
Coal Used—Pounds per Car Mile.....	3.6603	4.6105		
Coal—Monthly Consumption, Based on 14,000,000 Car Miles. Tons....	25622.1	32273.5	2	
Ashes and Clinker—Monthly Accumulation. Tons.....	2029.27	2362.41		
Number of Cars (40,000 Pounds Capacity) Required to Handle Coal— per Month.....	1283	1619		

TABLE VII.

RESULTS OF PRACTICAL AND LABORATORY COAL TESTS

PRACTICAL TEST BY 20x26-INCH CONSOLIDATION ENGINE 700, ON CHICAGO DIVISION, C. C. C. & ST. L. RAILWAY,
BETWEEN INDIANAPOLIS AND CINCINNATI

EAST-BOUND TRAINS	A		D		B		E		C		F		G		H	
	Trip 1	Trip 3	Trip 5	Trip 7	Trip 9	Trip 11	Trip 13	Trip 15	Trip 17	Trip 19	Trip 21	Trip 23	Trip 25	Trip 27	Trip 29	Trip 31
Train Number and Date.....	98. 5-1-98	98. 5-3-98	98. 5-5-98	98. 5-7-98	98. 5-9-98	98. 5-11-98	98. 5-13-98	98. 5-15-98	98. 5-17-98	98. 5-19-98	98. 5-21-98	98. 5-23-98	98. 5-27-98	98. 5-29-98	98. 6-13-98	98. 6-16-98
Run between.....	Indianap. and Mill Creek	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
Distance in Miles.....	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5
Leaving Time.....	11.30 a.m.	11.30 a.m.	1.00 p.m.	11.30 a.m.	12.45 p.m.	11.30 a.m.	11.30 a.m.	11.30 a.m.	11.30 a.m.	11.30 a.m.	11.30 a.m.	11.30 a.m.	12.00 M.	11.30 a.m.	11.30 a.m.	11.30 a.m.
Arriving Time.....	5.50 p.m.	6.20 p.m.	8.55 p.m.	7.40 p.m.	7.50 p.m.	7.30 p.m.	7.45 p.m.	6.40 p.m.	7.40 p.m.	8.40 p.m.	7.40 p.m.	8.30 p.m.	7.45 p.m.	5.45 p.m.	7.50 p.m.	7.10 p.m.
Delayed Time—"Stops"—Hours and Minutes.....	0-30	1-13	1-06	1-35	1-06	1-26	1-25	1-35	1-30	1-21	1-40	1-28	1 18	0-45	1-15	1-20
Actual Running Time—Hours and Minutes.....	5-50	5-37	6-49	6-35	5-59	6-34	6-50	5-35	6-40	7-49	6-30	7-32	6-27	5-30	7-03	6-20
Cars—Number Loaded in Train.....	40	44	41	44	47	44	42	42	46	45	44	39	43	48	40	44
Cars—Number Empty in Train.....	1	0	2	2	0	3	1	1	2	0	1	1	0	2	2	0
Cars—Total Gross Weight of Train in Tons, 2,000 lbs.....	1447	1448	1450	1447	1475	1454	1440	1458	1482	1489	1490	1475	1454	1475	1462	1452
Coal—Total Used, in Pounds.....	14074	13140	17596	18271	13818	15780	14557	13778	18400	17810	18900	16840	14697	16612	13888	15832
Water—Total Used, in Pounds.....	92274	81458	94978	94640	90584	95316	99034	95992	88218	90584	105794	97003	89570	87880	99034	100724
Average Boiler Gauge Pressure, Pounds.....	185	185	180	183	180	180	190	190	178	180	185	188	189	189	178	178
Rate of Evaporation—Pounds of Water per Pound Coal.....	6.556	6.199	5.397	5.179	6.555	6.040	6.803	6.966	4.794	5.086	5.687	5.760	6.090	5.290	7.131	6.362
Coal Used—Pounds per Ton Mile.....	.0604	.0840	.1129	.1174	.0871	.1009	.0940	.0879	.1155	.1113	.1178	.1062	.0940	.1047	.0884	.1014
Total Ton Miles Made.....	15552.5	155600	155875	155532.5	158562.5	156305	154800	156735	159315	160067.5	157950	158560.5	156305	158562.5	157165	156090
Weight of Ash and Clinker—Pounds.....	1129	1279	1060	1255	1618	1618	770	906	1860	1868	1444	987	1336	1143	1588	1537
Initial and Number of Car that Coal was taken from.....	W. & M. 1512	W. & M. 1512 C. H. & D. 4942	C. S. & H. 4114	C. S. & H. 4114	Big 4 27861	Big 4 27861	L. S. & M. S. 30014	L. S. & M. S. 30014	Big 4 27938	Big 4 27938	C. C. C. Co. 639	C. C. C. Co. 639	C. & O. 3025	C. & O. 3025	C. S. & H. 3013	C. S. & H. 3013

WEST-BOUND TRAINS																	
	Trip 2	Trip 4	Trip 6	Trip 8	Trip 10	Trip 12	Trip 14	Trip 16	Trip 18	Trip 20	Trip 22	Trip 24	Trip 26	Trip 28	Trip 30	Trip 32	
Train Number and Date.....	95. 5-2-98	95. 5-4-98	95. 5-6-98	95. 5-8-98	95. 5-10-98	95. 5-12-98	95. 5-14-98	95. 5-16-98	95. 5-18-98	95. 6-1-98	95. 5-22-98	95. 5-26-98	95. 5-28-98	95. 5-30-98	95. 6-15-98	95. 6-17-98	
Run between.....	Riverside and Indianap.	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	
Distance in Miles.....	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	
Leaving Time.....	9 45 a.m.	9 50 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	9 45 a.m.	
Arriving Time.....	3 50 p.m.	4 50 p.m.	5 10 p.m.	3 30 p.m.	5 10 p.m.	4 30 p.m.	4 45 p.m.	3 10 p.m.	4 35 p.m.	4 40 p.m.	4 10 p.m.	5 10 p.m.	4 55 p.m.	3 00 p.m.	4 50 p.m.	4 50 p.m.	
Delayed Time—"Stops"—Hours and Minutes.....	1-15	1-33	2-32	0-50	1-52	1-35	1-43	1-05	2-40	1-25	0-40	1-53	1-10	0-30	1-20	1-0	
Actual Running Time—Hours and Minutes.....	4-50	5-27	4-53	4-55	5-33	5-10	5-17	4-20	4-10	5-30	5-45	5-32	6-00	4-45	5-45	6-05	
Cars—Number Loaded in Train.....	29	33	29	23	25	30	25	30	30	32	31	30	25	25	30	28	
Cars—Number Empty in Train.....	0	0	0	2	0	0	1	0	0	0	7	3	6	0	1	5	
Cars—Total Gross Weight of Train in Tons, 2,000 lbs.....	806	826	827	808	804	830	785	868	813	802	815	807	799	801	809	811	
Coal—Total Used, in Pounds.....	12811	12481	15540	15470	13116	13870	11470	13080	17080	16765	12815	14305	13360	14239	15491	13412	
Water—Total Used, in Pounds.....	80782	86866	89570	83148	79092	83148	80106	86528	88894	81120	82134	86866	79430	80444	91598	83824	
Average Boiler Gauge Pressure.....	185	185	178	185	178	180	190	190	180	189	178	189	189	187	178	180	
Rate of Evaporation—Pounds of Water per Pound Coal.....	6.305	6.959	5.120	5.763	6.080	5.994	6.983	6.615	5.204	4.838	6.770	6.070	5.940	5.650	5.913	6.250	
Coal Used—Pounds per Ton Mile.....	.1528	.1451	.1806	.1840	.1568	.1606	.1405	.1448	.2020	.2009	.1512	.1704	.1607	.1708	.1841	.1500	
Total Ton Miles Made.....	83824	85904	86008	84032	83616	86320	81640	90272	84552	83498	84760	83928	83696	83304	84136	84344	
Weight of Ash and Clinker—Pounds.....	925	825	1255	1339	1295	1305	860	725	1880	2100	1065	1050	1100	1270	1436	1340	
Initial and Number of Car that Coal was taken from.....	C. & O. 13199	C. & O. 14097	C. S. & H. 6083	C. S. & H. 6083	C. L. & W. 3080	C. L. & W. 3080	Btg 4 12117	Btg 4 12117	Btg 4 22254	B. & O. 53629	C. & M. 3144	C. & M. 3144	P. R. R. 9099	P. R. R. 9099	C. S. & H. 3329	C. S. & H. 3329	

RECAPITULATION GENERAL AVERAGES—ALL RUNS								
Coal—Pounds Used in Hauling 1,000 Tons, One Mile. Engine 700.....	118.075	148.725	126.350	116.800	157.425	136.400	132.550	133.225
Water—Pounds Evaporated per Pound Coal. Engine 700.....	6.504	5.364	6.104	6.841	4.980	6.071	5.740	6.414
Water—Pounds Evaporated per Pound Coal. Purdue University.....	5.9	5.1	5.6	6.4	5.1			
Water—Pounds Evaporated per Pound Coal. Calorimeter Test.....	14.206	13.414	14.256	14.602	13.414	14.355	13.741	13.612
Coal Used—Pounds per Car Mile.....	3.6603	4.6105	3.9160	3.6208	4.8802	4.2284	4.1060	4.1299
Coal—Monthly Consumption, Based on 14,000,000 Car Miles. Tons....	25622.1	32273.5	27417.6	25345.6	34161.4	29598.8	28763.0	28909.3
Ashes and Clinker—Monthly Accumulation. Tons.....	2029.27	2362.41	2814.05	1562.81	3758.44	2141.18	2367.19	2910.01
Number of Cars (40,000 Pounds Capacity) Required to Handle Coal— per Month.....	1283	1619	1371	1268	1708	1480	1438	1446

Trip 12	Trip 14	Trip 16	Trip 18	Trip 20	Trip 22	Trip 24	Trip 26	Trip 28	Trip 30	Trip 32
95. 5-12-98	95. 5-14-98	95. 5-16-98	95. 5-18-98	95. 6-1-98	95. 5-22-98	95. 5-26-98	95. 5-28-98	95. 5-30-98	95. 6-15-98	95. 6-17-98
Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
104.	104.	104.	104.	104.	104.	104.	104.	104.	104.	104.
9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.	9.45 a.m.
4.30 p.m.	4.45 p.m.	3.10 p.m.	4.35 p.m.	4.40 p.m.	4.10 p.m.	5.10 p.m.	4.55 p.m.	3.00 p.m.	4.50 p.m.	4.50 p.m.
1-35	1-43	1-05	2-40	1-25	0-40	1-53	1-10	0-30	1-20	1-0
5-10	5-17	4-20	4-10	5-30	5-45	5-32	6-00	4-45	5-45	6-05
30	25	30	30	32	31	30	25	25	30	28
0	1	0	0	0	7	3	6	0	1	5
830	785	968	813	802	815	807	799	801	809	811
13870	11470	13080	17080	16765	12815	14305	13360	14239	15491	13412
83148	80106	86528	88894	81120	82134	86866	79430	80444	91598	83824
180	190	190	180	189	178	189	189	187	178	180
5.994	6.983	6.615	5.204	4.838	6.770	6.070	5.940	5.650	5.913	6.250
.1606	.1405	.1448	.2020	.2009	.1512	.1704	.1607	.1708	.1841	.1590
86320	81640	90272	84552	83498	84760	83928	83006	83304	84136	84344
1305	860	725	1880	2100	1065	1050	1100	1270	1436	1340
C.L. & W. 3080	Big 4 12117	Big 4 12117	Big 4 23254	B. & O. 53629	C. & M. 3144	C. & M. 3144	P. R. R. 9099	P. R. R. 9099	C.S. & H. 3329	C.S. & H. 3329

26.350	116.800	157.425	136.400	132.550	133.225
6.104	6.841	4.980	6.071	5.740	6.414
5.6	6.4	5.1	.....	.....	.....
14.256	14.602	13.414	14.355	13.741	13.612
3.9160	3.6208	4.8802	4.2284	4.1090	4.1299
7417.6	25345.6	34161.4	29598.8	28763.0	28909.3
2814.05	1562.81	3758.44	2141.18	2367.19	2910.01
1371	1268	1708	1480	1438	1446

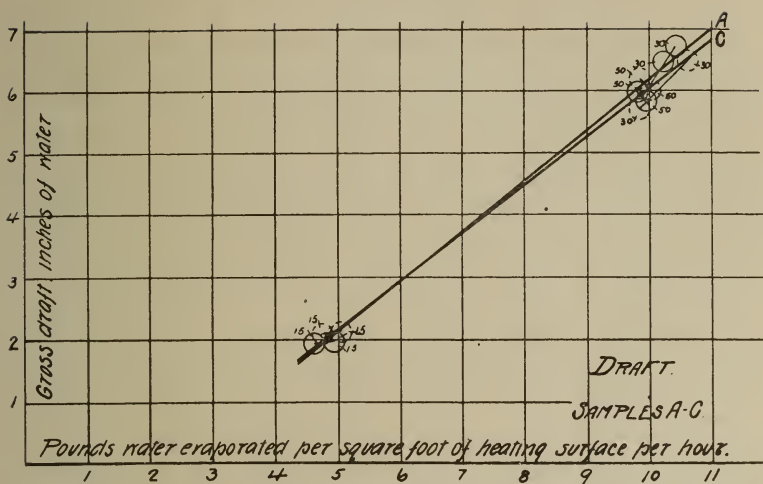


FIG. 10.

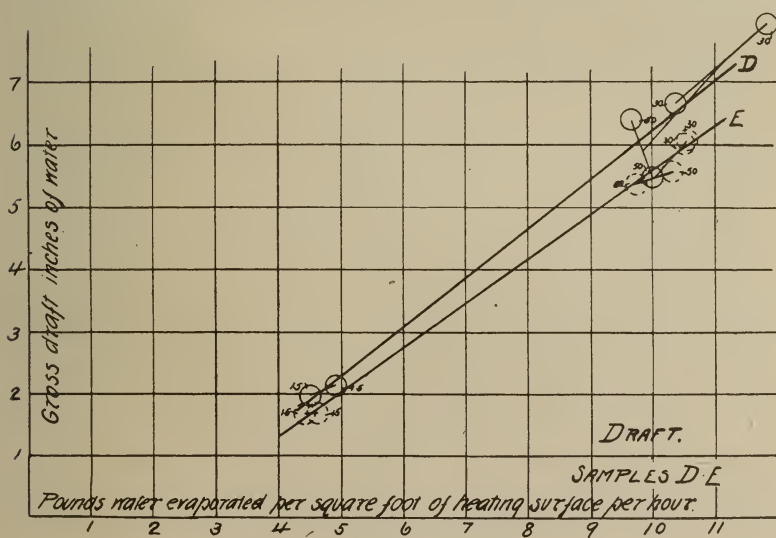


FIG. 11.

DISCUSSION.

THE SECRETARY: Mr. Garstang can not be present, but Mr. R. L. Ettinger, mechanical engineer of the road, is present, and he will answer such questions as may be proposed; and Prof. Wm F. M. Goss, of Purdue University, who was interested in the laboratory experiment, will make some remarks. Circumstances require that the Secretary call your attention to some of the features of Mr. Garstang's paper. It has been suggested that a skeleton of the paper be read, but I think that the meat of the paper is in the skeleton part of it, as represented in the tables, the first being Table I, which shows the actual evaporation when the rate of evaporation per square foot of heating surface was five pounds, and ten pounds of water. Column II shows the different rates for the different kinds of coal given in the first column, and when the rate of evaporation was increased to ten pounds, you will notice by the third column, that the pounds of water evaporated per pound of coal was materially reduced. In Table II is given the spark losses, and with Table II should be considered Table III, because, as said in the paper, a coal which leaves a light refuse in the ash-pan but which leaves most material in the smoke-box may not lose any more in the way of sparks than the coal which leaves a heavy refuse in the ash-pan and less refuse and sparks in the smoke-box; in the former case there may appear more ash in the smoke-box on account of the lightness of the refuse of combustion.

Table IV gives the percentage of clinker to dry coal, accounted for as clinker in ash, and Table V gives the draft, in inches of water, necessary to secure the evaporation of five pounds of water per square foot of heating surface per hour in Column I, and in Column III is given the draft necessary to produce an evaporation of ten pounds of water per foot of heating surface per hour. It is understood from experiments made previously, and also from the present one, that the method of securing the draft does not affect in any way the rate of evaporation per pound of coal, and that whether the draft be produced by the exhaust from the cylinders or by other means, the evaporation will be practically the same for the same draft. In Table VI an effort is made to show the value of each kind of coal, but it is explained that to determine just which is the best coal is a very difficult question. The tables mentioned refer only to the laboratory tests.

Table VII shows the result of tests made on the Big Four road in actual service, and you will note that the tests were made in both

directions over the same division on different dates, and that the data for the east bound runs and for the west bound runs are tabulated separately. In these tests an effort was made to maintain the weight of train nearly uniform and to have the conditions as nearly uniform as possible. At the bottom of this table is a recapitulation, and certain data is given referring to the road test and also certain other data referring to the laboratory tests, and from these an effort is made to draw comparative conclusions, but they may be or may not be correct, because the boilers of the two engines used in the test, that is, the boiler of the laboratory engine and the one of the road engine were not similar. The road engine had a much larger boiler than the laboratory engine.

The principal dimensions of the two locomotives having been asked for at the meeting they are furnished below, but Mr. Garstang desires that it be understood that the tests were made for fuel comparison only, and were not boiler tests.

	PURDUE LOCOMOTIVE.	"BIG 4" LOCOMOTIVE NO. 700.
Cylinders.....	16 x 24 ins.	20 x 26 ins.
Drivers.....	69 ins.	51 ins.
Boiler diameter,—waist.....	52 ins.	64 ins.
Fire box—length.....	72 ins.	113 $\frac{1}{2}$ ins.
“ “ width.....	34 $\frac{1}{4}$ ins.	41 $\frac{1}{8}$ ins.
“ “ depth.....	79 ins.	Front 72 $\frac{1}{2}$ ins., back 69 $\frac{1}{8}$ ins.
Water Space—front.....	4 ins.	4 ins.
“ “ sides.....	3 ins.	3 $\frac{1}{2}$ ins.
“ “ back.....	3 to 4 ins.	4 ins.
Number Tubes.....	200.	320.
Diameter tubes.....	2 ins.	2 ins.
Length tubes.....	11 ft 6 ins.	13 ft. 6 ins.
Grate area.....	17 sq. ft.	32 3 sq. ft.
Heating surface—fire box.....	126 sq. ft.	175.34 sq. ft.
“ “ tubes.....	1196 sq. ft.	2264 sq. ft.
“ “ Total.....	1322 sq. ft.	2439 sq. ft.

It was suggested, also, that the relative price of each kind of coal would add much to the value of the paper, and this information Mr. Garstang has furnished and the same is given below. It was assumed that coal "E" cost \$1.50 per ton and the price of each coal was calculated on that basis.

RELATIVE PRICE OF COAL PER TON, IF COAL "E"
COST \$1 50 PER TON.

A	D	B	E	C	F	G	H
\$1.272	\$1.262	\$1.262	\$1.50	\$0.931	\$1.293	\$1.221	\$1.210

PROF. WM. F. M. GOSS (Purdue University): Mr. Garstang's paper presents several matters concerning which I would like to speak.

First of all, I would suggest that the paper represents a very extensive piece of work. In outlining the tests for the laboratory, Mr. Garstang specified that tests should be made at fifteen miles an hour under conditions of cut-off similar to that of starting or switching; at thirty miles an hour with a somewhat shorter cut-off to give conditions similar to freight service; and at fifty miles an hour with short cut-off representing passenger service. Two tests were made under each of these conditions, making six tests per sample. The fifteen-mile tests were continued for four hours, and the thirty and fifty mile tests, each for three hours, making the total running in the laboratory for each sample of coal tested, about 600 miles, an amount of running which even exceeds that accomplished by Mr. Garstang in the process of road tests.

It goes without saying that the most important conclusion disclosed by the paper is pounds of water evaporated per pound of coal, for the various samples as shown in Figs. 1 and 2. We all know that in locomotive service we get more steam per pound of coal burned, when the boiler is worked at light power than when the boiler is worked at heavier power. In the results before us the rate of power is plotted along the horizontals and the evaporation per pound of fuel along the verticals, the slope of the lines such as E in Fig. 1, showing the change in efficiency which results from changes in power. Thus, the sample E, when the rate of evaporation is 5 pounds per foot of heating surface, evaporates 8.6 pounds of water per pound of coal, but when the rate of evaporation is increased to 10 pounds it only evaporates about 6.6 per pound of coal.

It should be noted that the values presented in the Tables, I to VI inclusive, are not those actually obtained in tests, but are derived from curves drawn through points representing tests. All comparisons are made for a rate of evaporation of five and ten pounds of water respectively, per foot of heating surface per hour.

Mr. Garstang calls attention to the fact that the character of the exhaust action does not materially influence the evaporative efficiency of the boiler. The efficiency at all times is a function of the rate-of-power at which the boiler is worked, which is equivalent to saying that the efficiency is a function of the draft. It appears to make no difference whether the draft is the result of a heavy exhaust action, such as is incident to low speeds, or to a lighter action such

as attends high speeds. If the draft produced is the same in both cases the evaporative efficiency of the boiler is the same. This fact is, I believe, well established not only by the tests under consideration but by many others made at the University. It implies that tests of fuel for use in locomotives can be made in a fixed boiler as well as in one which is influenced by the motion of the engine. Draft can be produced by a steady flowing steam-jet as effectually as by the pulsating action of the exhaust, so that there seems to be no reason why the whole problem can not be approached by means of a stationary boiler arranged to give draft conditions comparable with those found in locomotive practice. I first advocated a plan such as this, before the Club some four years ago, and I believe that we shall soon see small stationary boilers arranged to permit draft conditions comparable with those found in locomotive service, in common use by railroads for testing fuels.

The paper shows the relation of the evaporating efficiency to draft which must prevail for the several samples tested, in order that definite rates of evaporation may be sustained, which is of interest since it is likely that such a relationship has never before been defined for conditions applying to locomotive service.

In comparing results Mr. Garstang, in his table, gives figures which seem to show the Big Four engine, No. 700, to have a higher evaporative efficiency than the Purdue locomotive. Such a conclusion, however, is hardly justified by the facts, and I judge that Mr. Garstang in presenting the figures had no such purpose in view.

An examination of the data reveals the fact that the conditions under which the evaporative efficiency noted in the table was obtained, were such that both the Big Four engine and the Purdue engine evaporated practically the same total weight of water per hour; that is, both boilers were worked at the same power, but I assume that the Big Four boiler was much larger than the Purdue boiler and, hence, that relatively it was not forced to the same extent as the Purdue boiler. This fact, of course, will necessarily show to the disadvantage of the Purdue boiler. I imagine that if both boilers were made to evaporate the same weight of steam per foot of heating surface per unit of time, that they would give substantially the same evaporative efficiency.

MR. G. W. FARMER (A., T. & S. F. Ry.): There are some questions I would like to ask in reference to the table. The table

reads, "water evaporated per pound of dry coal;" does that mean that the moisture was ascertained and deducted from the weight of the coal handled? Also, in the road tests, was it necessary to take on coal between terminals and, if so, what facilities for weighing it were provided, and also for ascertaining the exact number of pounds which were used? I would like to know the details of the methods used.

MR. R. L. ETTINGER (C., C., C. & St. L. Ry.): In the locomotive tests no calculations were made for dry coal percentages and the amount of coal charged to the engine included that used in firing up and handling the engine from roundhouse to yard, and was the total amount of fuel charged against the engine. The water consumed was not measured by meter, but calculated by the number of inches used between water stations. At water stations the tank was always filled to overflowing and readings made on a gauge prepared for that purpose. There was no coal taken on the road; the coal was weighed on to the tank before the engine left the roundhouse, and what remained at the end of the trip was weighed; there was always some to weigh at the end of the trip. The amount of coal was taken with absolute accuracy, the amount of water consumed would vary by the small percentage lost at the injector overflow.

MR. G. W. RHODES: I would like to ask Mr. Ettinger a question. Near the close of the paper it is said that, "The problems are difficult to determine, as you will note by the table that the coal that gives the greatest efficiency has the greatest evaporative value, maintains the maximum steam pressure," etc., and then farther on says, "When compared with the cheapest fuel tested, which has the disadvantage of being a poor 'steamer,' has the lowest general efficiency, evaporates the least amount of water, etc., shows, on account of its price, to be the cheapest fuel per ton of freight hauled." Do I understand from that, that the best coal is the cheapest per ton of freight hauled?

MR. ETTINGER: No, sir; the cheapest coal per ton is the cheapest per ton of freight hauled.

MR. RHODES: I am very much interested in that paragraph, because that is a question which the motive power department, especially the master mechanics, have been for a number of years trying to prove; they have been trying to prove that the coal that has the least amount of ashes and that gives the greatest evapora-

tion is the best coal to be used on railroads, and every time they attempt to prove it they fail. The Pennsylvania railroad, twenty-five years ago, took up that very question and the results of their investigations were, that the highest priced coal and the coal that had the least amount of ashes was not the cheapest per ton of freight hauled, and it interested me very much to see this statement again appearing. As a master mechanic, I wish it could be shown some other way, but it is a fact that the conclusions which the Pennsylvania road reached twenty-five years ago were about this: With certain grades of coal, I will not say of coal that is too bad to use, because we do occasionally get grades that are too bad to use, but in any coal that is good enough to use on a railroad, it will be found that the low grade coal is the cheapest for operating, and is the cheapest because it does not burn. If a railroad company can put up with getting its freight and passenger trains between terminals with occasional failures, it will be found that, within prescribed limits, commercial values are so fixed that for locomotive use the fuel which costs least will be found the cheapest to use.

MR. F. A. DELANO (C., B. & Q. Ry.): I wish to ask Mr. Ettlinger, or Prof. Goss, if any of these results shown in the different figures have been plotted in relation to the evaporation per square foot of grate area? The reason I ask this is that it seems to me there is a possible error due to referring the evaporation to the square foot of heating surface. In the first place it has often occurred to me that the square feet of heating surface represent a good many different kinds of square feet. The square foot of heating surface in the fire box, where exposed to the red heat of the flames, is certainly a good deal more effective and efficient than the square foot of heating surface at the forward end of the tubes. Now, there is another reason why there is a good deal of variation and difference in the practice on different roads; the relation of the grate surface to heating surface, and I, for one, would like to see side by side with these diagrams, diagrams figured and plotted in relation to these grate areas.

MR. F. G. GASCHE (Illinois Steel Co.): The Club and all railway interests are certainly indebted to the author of the paper and to Professor Goss for their painstaking efforts in the collection of experimental data on a rational basis which renders the comparison of locomotive fuels a possibility. The speaker has employed a similar method in the study of the performance of stationary boilers. Mr.

Garstang has favored the railway fraternity with the evidences of the important law, clearly applicable to locomotive boilers as well as to stationary boilers, that an increase in the rate of combustion of the fuel is accompanied by a decrease in the equivalent evaporation from and at 212 deg. F. per pound of fuel. Where so much valuable material is assembled in the paper the speaker hesitates to offer anything in criticism, as he would detract nothing from a paper so important. It will do no harm, however, to venture certain conceptions which may assist in the interpretation of experimental results of this nature, and they are submitted with the hope that they may be of service in the future.

The graphical representations, Figs. 1, 2, 3 and 4, have been used more or less frequently in the study of boilers of the stationary or marine type. The likeness consists in the development of the curves of boiler performance on a diagram whose co-ordinate axes are respectively:

Equivalent evaporation per pound of coal; and

Equivalent evaporation per hour per square foot of heating surface.

The use of these co-ordinates implies that there is a necessary relation between the two quantities which may be expressed by some empirical law. Transforming the statement of the lines A, B, C, etc., on the diagram to words, we say: As the amount of water evaporated per square foot of heating surface increases, the evaporation per pound of fuel decreases. This is clearly a statement in abbreviated form of the efficiency of the heating surface. It does not, of itself, give evidence of the relative value of the different coals. Let us examine if any necessary relation exists between the two quantities shown on the diagram, e. i. Fig. 3.

E = lbs. of water evaporated from and at 212 deg. F. per pound of the dry coal.

W = lbs. of water evaporated per hour per square foot of heating surface, from and at 212 deg. F.

F = lbs. of dry coal burned per hour per square foot of heating surface.

A and K are empirical constants.

From considerations of the efficiency of heating surface it is known that :

$$E = \frac{K}{1 + A F} \quad (1)$$

The diagram Fig. 3 asserts that :

$$W = f(E) \text{ a function of } E. \quad (2).$$

Equation (2) would then read :

$$E = \frac{W}{F} = \frac{K}{1 + A F} \quad (3)$$

This equation may be expressed as follows: The water evaporated per square foot of heating surface is a function of but one quantity, viz: The coal burned per square foot of heating surface. This, while self-evident, is no indication of the relation between the evaporation per pound of dry coal and the rate of combustion of the coal.

It is therefore suggested that the co-ordinates used in studying the results of locomotive boiler tests be shown on a diagram whose co-ordinates are:

Pounds of water evaporated from and at 212 deg. F. per pound of dry coal; and

Pounds of coal burned per hour per square foot of heating surface.

It may be possible that this method of comparison of the different kinds of coal may alter the numerical values shown in Table I, though their relative value cannot be predicted until a diagram is constructed. The forms of diagrams shown in the paper are certainly valuable, but the comparative value of different fuels could be shown to great advantage in the manner just outlined.

PROF. GOSS: In answer to questions which have been asked, I would say that the amount of moisture in the coal fired was determined by the process already suggested. A sample of from 60 to 100 pounds was shoveled into a large galvanized iron pan, the lumps were broken to a uniform size, and the whole allowed to dry until dusty. The correction for moisture was in all tests small.

With reference to the question raised by Mr. Delano, and which has been so ably presented by Mr. Gasche, I would say that it seems to me that the whole question hinges on the purpose underlying the tests. If an analysis of the action of the boiler is sought, then the criticism which has been urged by the last speaker would certainly have weight, but in the present work the purpose was to determine the relative value of the different coals. A fundamental condition required the boiler to develop the same amount of power, that is, to make the same amount of steam per unit of time, in tests which were to be comparable for each of the several samples. By keeping the action along the heating surface constant, and allowing variations to come in the rate of combustion, the information desired was obtained, for the results then showed the variations in the amount of coal required to do a definite amount of work. This being true, it seemed wise to present the results in substantially the same form in which they were obtained.

PROF. L. P. BRECKENRIDGE (University of Illinois): I was attracted to this meeting because I saw there was a professor connected with the paper for to-day, and being a professor myself, as I only joined the society a few months ago, I thought this would be a good time to make my bow.

From the side of the technical school, the fact cannot be emphasized too much that the amount of work involved has been great. At the University of Illinois we have attempted to make various tests of locomotives, and after working for a few weeks on some experiments, have found that they were good for nothing and must be thrown away. You are not certain in performing a series of tests that they will be of any value. The more I have to do with railway men, the more I believe that nothing seems to be good for anything. As soon as a professor establishes a fact that he proposes to run the railway world with, and brings it to the society and talks about it, the moment he sits down somebody gets up and says "but," and then follows a talk that knocks out all he has said.

Now, there are a great many things about this paper which can be said. I emphasize again the fact that it has involved a large amount of work on the technical school side, as represented by the Purdue University, also a large amount of time and care and work on the part of the railway corporations in order to check, in actual practice, the results of the laboratory determinations. These tests, to me, have two very important values. First, they place on record something that has been done carefully. While we are not able, perhaps, to make any deductions from the article as shown in the paper, it will only be a short time before added experiments will be made, and from the sum of all our existing experiments, as we collect them from year to year, we shall soon be able to say with considerable certainty what will follow when certain proportions are laid down as ratios of grate area and heating surface and amount of coal and kind of coal used with various draft pressures, and other relations. They can never be laid down so that everybody can follow any exact rule, but it is only on account of the large number of experiments which have been carefully carried out with stationary boilers and stationary engines, in the collecting and combining of all these experimental results all over the country, that the stationary engines have reached the perfection in which they now exist. It is very difficult to make locomotive tests, either on the road or in the

laboratory. The conditions and the chances of variation, especially with all the varying kinds of coal that exist all over this part of the country, render that problem almost hopeless. However, it is only after we have all taken hold and contributed a little here, and a little there, that we will be able to formulate and get up something that will be valuable.

There is another value to this work. Here in this paper are grouped two concerns—a leading technical school of the middle west, and a large railway corporation. Everybody knows that the technical schools of the country are growing rapidly, and coming rapidly to the front all over the middle west; the technical schools are surpassing in equipment, number of students (and, I was going to say, able professors, on account of Professor Goss' position, but perhaps I had better omit that on account of my own) many schools in other parts of the United States, and even in Europe. It seems to me that the technical school and the railway club and the engineering society ought to be of great value to each other. Our libraries are filled up with records of the world, relating to locomotive performance. The railway man seldom has time to group together all these facts; he seldom has the literature at hand, if he had the time or could employ men to do the work. The libraries of the large universities and technical schools seem to contain the world's information on this subject, and it seems to me that the technical schools are in a position to get together in a systematic sort of way, and from time to time present the facts so that the clubs will get considerable benefit from them. On the other hand, the technical schools of the country are always in need of the co-operation of large industrial and railway enterprises. The technical schools are always anxious to take hold of this work, and other problems that they see can be of some value to the technical clubs. The clubs ought, on the other side, to present these subjects to the technical schools and say, "Why can not you find out this and that for us?" Do not let mechanical engineering professors go hunting around for something to do. All the technical schools ought to be flooded with work that they can not do on account of the demand on their services.

I suppose this might be an argument against what I said, but I will say that, in Germany, when anything new comes up, everybody does not get an opportunity to handle it and see what happens to it. For instance, what happens to acetylene? In America, anybody is

permitted to handle it and find out what happens to it, and blow himself up with it. They do not let anybody have acetylene there; they put it into the technical school and say, "There, find out what that will do." They do not blow up anybody in Germany. That is what ought to be done in the west; when technical questions come up that you would like to have solved, go to the technical schools; they are all over the west; they have great laboratories; they are anxious to do it; you ought to bring these problems before them.

There are some things in relation to this paper I would like to find out. In the first place, a professor is always finding fault; he is criticising drawings and examination papers and all those things that come into the office, and we invariably find ourselves criticising a paper and picking out the weak points and very seldom think it is necessary to say, "That is a fine paper." I think I have complimented the paper.

Now, this paper, to me, would be more valuable if I knew the proportions of locomotive 700. I understand that possibly it was the idea to publish the proportions of the locomotive in the Proceedings. It seems to me that that should be done. Information to what the locomotive had done in practice would be more interesting to us if we knew how near it came to the five or ten pounds of water evaporated per square foot of heating surface, as in the laboratory tests. As to the method of weighing coal and water, there is a committee of the American Society of Mechanical Engineers now struggling with the question of standard locomotive road tests. If you have ever tried to weigh water in locomotive tests, you have found some difficulty involved. It is a question of what is the best way of doing it, and I would like to get information; I would like to know what the method of calculating the water in this test was—whether by giving the number of cubic feet in the tank, or whether the tank was calibrated by filling in up to the different inch marks in the scale that was used.

As to the relative cost of the coal. A professor cannot understand why it is that a committee on those couplers should not hesitate to knock any number of couplers "gally-west" and be so careful of the coal fellows. I do not understand why you did not publish coal prices. It seems to me that the question of kind of coal is a question of considerable importance to us. There is not much difference in these coals. The calorimeter tests, the fourth item on the recapitu-

lation—"Water: pounds evaporated per pound of coal," etc.—I understand means that the total number of heat units were determined by calorimetric tests, and it varied from 14.6 to 13.4, which is the lowest here—very little difference. Now, if the fellow did not want to tell how much that coal cost, he could certainly have said, on the basis of the coal "E" costing one dollar, coal "A" cost $87\frac{1}{2}$ cents, for instance, and that would have given us a chance to see the relative value of the coal. I understand that when you burn coal you want to produce as much steam for a dollar as possible. May be that is wrong, but it seems to me that is what you want; you want to make all the pounds of steam possible for a dollar, and you do not care what kind of a locomotive you make it with, provided it is heavy enough to pull as many tons of freight as is required of it over the road, and the locomotive does not cost too much. The relation between the cost of coal, I think, ought to be added to this paper. I see no reason why that should not be the case. This coal "E" must be West Virginia coal, or some other kind. Certainly, you cannot mine that kind of coal in Illinois; you cannot get coal in the State of Illinois that would have as high as 13,000 heat units; it is almost always 10,000 to 11,000—once in awhile you get 12,250 heat units per pound of Illinois coal. Illinois has got about the poorest coal, but it has got the most of it. It may be that this road over here that finds it is the best scheme to burn a bad cheap coal, knows how to burn it. If you only know how to burn it, you can get fairly good results out of it. We get better results burning Illinois coal with 11,000 heat units than is shown by the results here. You do not get 45 per cent. of the heat units, and that is a very poor showing. Of course, locomotives, as a general thing, do not do much better than that, and I am not sufficiently familiar with locomotive practice to criticise the performances of these locomotives, because, as I say, there is not a great amount of data on the subject of locomotive boiler performance.

About vacuum in the smoke-box, that is a very important thing. Prof. Goss says, and I am inclined to believe that it is so, "If in each case the boiler is forced to the same power, the same degree of efficiency results." Now, that is a very important thing. It occurs to you, perhaps, that you carry a high back pressure on the piston in order to get more exhaust. If you could in any way reduce that back pressure and still keep up the vacuum in the smoke-box, you

would get that much more hauling capacity out of your engine and you would get the same efficiency that you can now, if this is all so. I am inclined to think it is so, but it means a lot. Instead of building boilers to carry 225 pounds pressure, instead of 200 pounds, in order to get more capacity out of your locomotive, if you can keep up the vacuum and take that same back pressure off the piston you can get a greater amount of hauling capacity at much less expense. Any scheme you can get up to decrease back pressure, would not, within reasonable limits, interfere with the rate of combustion, if I understand this application correctly.

What are these little circles and figures shown in the diagram? I suppose they mean something, probably Professor Goss will tell us what. These are the same kind of diagrams professors always make; they are what I teach my students to make, and sometimes they do not mean anything to a railroad man. But then do not think because you do not know anything about them, that they are not good for anything. We professors are on the same footing; there is another end to this thing. Lots of times we do not know anything about a scheme, but find it is a good thing. These little circles around here, these little dots, mean these experiments were carried on conscientiously and carefully. I remember when I was a student at Yale we used to have a survey to make around an old cemetery, and one of the first jobs the sophomores had was to run a line around that cemetery and back, and it took pretty nearly three hours to make it, and if we did not get it within a foot or so, we had to do it again. Well, the section that I was in had got that thing all planned out and thought we were going at it about right, and we got it within .015 of a foot, but then the professor said, "That is too near, do it again." Now, that accounts for these little circles in these diagrams. If you make an experiment and you stick to what you get, and do not draw it one way or the other, and do not make it come on a line, you put down facts, and that is all you want in a society like this; you do not want these points on a line. In tests like this, you can not take a car load of coal and make five boiler tests with the same boiler and with the same conditions and get the same results five times; if you do honest work you can not duplicate the results exactly. You are just as liable to get 5 or 6 per cent. off as you are to get all alike. So, I say, these little corrections, not all appearing on the same line, mean that the curved line has been laid down

as the average result of the experiments that have been performed, and it shows honest work.

I wish we had a record of the temperature in the smoke-box. If you use only 45 per cent. of the heat units, I would like to know where the other heat units go. If there is 55 per cent. of the money that you put into coal going out of the smoke-stack, it seems to me there is a chance to study a little bit in connection with these other things, for you can never save until you know where the losses are, and it seems to me a study of losses is always an important thing in any problem. The subject of temperature in the smoke-box I was rather interested in, from other experiments that we had under way recently at the University of Illinois. It does not follow from Fig. 2 that if you can go one way along these curves you can also go the other. As the water evaporated per square foot of heating surface increases, your efficiency changes, *i. e.*, the evaporation per pound of coal decreases, but you can not produce these lines toward the left and expect to determine the efficiency for low rates of evaporation.

There is another important thing in practical tests on the road. It seems to me that enough importance is not given to the subject of time in making comparative tests. Here is one trip that took seven and one-half hours, and another that took four hours and ten minutes, and still you are comparing the evaporating efficiency of the boiler for these two trips; what was it doing those three hours in the latter case? You have charged all the coal up against it; it is a question as to how the allowance ought to be made. There ought to be an allowance made for the stopping and starting at stations.

The question that Prof. Goss has brought up, relating to the fact that we can test a locomotive boiler and get its evaporative efficiency even if it is not run on the road is, I believe, entirely correct. Within the last six months, at the University of Illinois, we have had a locomotive, very kindly furnished by the Illinois Central Railroad, with which we undertook to determine some relation between the evaporative efficiency when it was all full of scale and when it was clean. We made three separate tests under each condition. Now these results we are working up at present, and the method of obtaining the draft was simply to block the slide valve and let the steam from the boiler stream through the exhaust nozzle into the stack. You can in this way regulate the evaporation of the boiler beautifully, and any boiler that you have on the road may be easily

tested by any of your experts without any difficulty. The relations which we got for the different conditions of scale, and no scale, amounted to a difference of about $9\frac{1}{2}$ per cent. for the two conditions, and you may be interested a little later in the report of these tests

MR. A. E. MANCHESTER (C., M. & St. P. Ry.): Referring to Prof. Breckenridge's criticism about the time of the making of the run; from a railroad man's standpoint we generally consider that the more hours we have in which to do the work, the greater efficiency we can expect to get out of the fuel, and I think this paper will bear me out in such remark, and it is shown in this case that the rapid runs were more expensive for fuel than were the slow runs.

Certainly, the question of using high priced coal, as referred to in the paper and by Mr. Rhodes, the experience of the Milwaukee railroad, directly confirms what has been said on the subject. I have never explained it in just the way that Mr. Rhodes puts it, but have always considered that the price of the coal was greater in proportion to its heating value than was the case with the lower grades of coal. The lower grades of coal in the west being abandoned and the high grades of coal having to be brought a long distance, the better grades of coal were charged up at a price that was greater than their actual value when compared with the western grades of coal. The fact that different grades of coal require a different draft emphasizes, in railroad practice, the fact that we should not mix our coals to any great extent; that we should, as far as it is possible to do, keep coal for use in a certain lot of engines that can be adjusted to the best draft for that coal.

The method of making the road test is one that we have followed at different times in determining the value of coal, with this exception, that whenever we have coal to test on the road we take two engines of the same class, and in as nearly the same condition as we can judge, and take what we call our standard coal to be burned on one engine for a certain number of trips, and on the other the coal to be tested; then we reverse the coal, running the same number of days with practically the same weight of train for both engines, trying both engines with both grades of coal; we also get the two grades of coal tested on the same day. I find another condition that arises in actual practice relative to the quality of coal; I think possibly everybody has had some experience, or the same experience, that as

soon as the fall comes and freezing weather is with us, the coal grows worse very fast, and the same coal which a few weeks before was giving excellent service, we at once hear a great deal about as not being good. I do not believe it is all due to the engines, or the harder work that they have to perform. In the summer those of us who are a few hundred miles away from the coal fields, get coal that has had an opportunity to dry out and become, possibly, very nearly in the best condition for locomotive use by the time we get it; while in the winter the coal comes out of the ground and is immediately frozen hard; we put it into our engines in that condition and we get very much lower efficiency from the same coal at such season of the year than we do earlier.

MR. W. H. MARSHALL (C. & N-W. Ry.): The question of making allowance for time lost on the road when conducting road tests, is a matter that every one of us has met in attempting road tests, but I do not quite agree with Mr. Manchester regarding the relation which the economy of the locomotive bears to the length of time on the road, at least not without modifying that statement. If we have, say, a hundred miles accomplished in five hours by a train that has no delays whatever, the average speed would be twenty miles an hour. If a train of the same weight goes over the road in, say, six hours, but stands on the side tracks for one hour, the average speed is the same, and the loss is that involved in starting the train more frequently, plus that which occurs while standing. On the other hand, if the train goes over the road in five hours, with one hour spent on the side tracks, the average speed is higher and the coal consumption much greater; all these things have to be taken into consideration.

As far as reducing the back pressure on our engines in order to increase their power is concerned, and the necessity of changing the arrangement in the smoke-boxes in order to make more steam with a larger nozzle, as suggested by Professor Breckenridge, that is the problem we have all been seeking to solve, and if any one looks at the problem as he should, the exhaust nozzle will be the last thing he will touch to make steam; but the fact is we often have it much smaller than we desire.

The statement in the paragraph near the close of the paper, in which Mr. Garstang says that the cheaper coals are used with less cost per ton of freight hauled, is now, I think, pretty well established

as a general proposition, and yet it is something that causes the motive power department considerable grief because we have to stand so many of the evils that result therefrom. The true limit to the economical use of cheap coal is generally found when the troubles caused by it, such as poor steaming engines, dirty fires, leaky boilers, etc., produce delays to traffic, particularly to important trains. The actual cost in cents of the coal consumed per ton-mile in both passenger and freight service will almost invariably be less with the cheaper coal, and this rule will hold good until carried so far that engine failures, delays to trains and generally unsatisfactory service become the leading factor in determining the course to pursue, rather than the cost of fuel per ton-mile.

Last year we had a pretty good illustration of the fact that high grade coal is the more expensive, all things considered. During the coal strike we obtained good coal via the lakes for our lines in Dakota and Minnesota; it cost us nearly double the price paid for what we had been using. All the engine men said they would make records which would show that the good coal was the cheapest to use, but the very best that was done was not much more than 50 per cent. better than the men had been doing with the poorer coal, and as it cost us nearly double, it certainly would not pay the company to continue to use it.

These coal tests recorded in Mr. Garstang's paper are particularly interesting to the mechanical department of the North-Western road, as we have in contemplation the conducting of some tests to determine the relative value of our coals. It is not so much that we desire to change coal, or to transport them greater or lesser distances because of the difference in their efficiency, as it is to obtain some check on our fuel consumption. When the record goes down in certain localities compared with previous months or previous years, and we try to ascertain the cause, we are often met by the statement that it was due to poor coal. Investigation may show that the coal is received from the same mines, and, as far as our investigation goes, may not be able to sustain or disprove the claim of poor coal. We thought that if we could make a series of tests to show the value of the coals in actual practice, and then have some method of checking these results later with a stationary boiler, we could quickly establish the truth or fallacy of any claim of poor coal. We contemplate making tests in actual locomotives on the testing plant, and then

making additional tests on a stationary boiler and if they will check sufficiently close we can establish the results in a small boiler as a standard, so that we can compare them afterwards readily. From what Prof. Goss says it would seem that this plan is perfectly feasible; we did not feel certain that it would be, but we thought we would make experiments to demonstrate whether it is or not.

MR. ROBERT MILLER (Michigan Central Ry.): I would like to ask a question in this connection: I did not believe, previous to attending this meeting, that the lowest priced coal was the cheapest to use. There is a paragraph, following the one referred to, in which Mr. Garstang says: "I cannot make a comparison between these coals relative to their effect on fire box and tube sheets, nor was this taken into consideration during the test." I would like to ask Mr. Rhodes or Mr. Marshall if that has ever been taken into consideration in any tests they have made?

MR. MARSHALL: I would say, as far as I am concerned, that in making the statement that cheap coals in general were the cheapest per ton of freight hauled, I did not include everything. Of course there are coals that are not fit to burn on locomotives, and the stops, troubles with sheets, clinkers, failures on the road, difficulty of handling engines at the stations—all these make the coal so expensive that you could not afford to use it, but there is a very wide range through which I think the rule holds good.

MR. F. SLATER (C. & N.-W. Ry.): I would like to say a word on this subject. When I was connected with the Milwaukee, Lake Shore & Western, the cheapest coal in our locality was \$3.10 per ton. When the Chicago & North-Western bought that road, coal was delivered to us the first year at a cost of about \$1.90 a ton. The cost for fuel under the Milwaukee, Lake Shore & Western management at \$3.10 per ton was something like 9 cents a mile for coal, and after we became a part of the North-Western and were furnished coal at the price to them, the cost was about 6 cents; repairs to locomotives was about 3 cents per mile, so we figured that the difference in the cost of coal covered the entire cost of repairs. In that case the boiler repairs were only a small part of the total.

PROF. BRECKENRIDGE: In regard to the question of cost of coal, and of using the cheapest coal; I think it is true that any kind of coal that is cheap and will keep up steam and haul the load that you are trying to haul, is the cheapest kind to burn. Take a house-

heating boiler, and you just keep on buying coal cheaper and cheaper until all of a sudden you find that you are buying coal that will not keep you warm, but as long as you have cheap coal and keep your house warm, that is what you want. Take any kind of a stationary plant, as long as you keep up steam, lowering the coal bill, the cheaper the steam. But there is another side to this question; you can not keep up steam with any front end construction that is not adapted to the particular kind of coal, and if you can not keep up steam, the next thing will be, you cannot draw near as many loads. I do not believe that you want efficient locomotives; there is not a man here who tries to run a locomotive efficiently. Every one that I have ever seen try to run a locomotive tries to get as much out of it as he possibly can; he starts out with just as much load as he can haul over the biggest hill alone, and sometimes he must "run for water," and do all sorts of things before he gets over with his train. That is not trying to run a locomotive efficiently. I have recently been out three weeks with five officials of a railway company making some pulling tests with a dynamometer car; these five officials were the men who send the trains over the road. When we came to a hill the question would be, how many loads can we take up, say fifty-four loads, with the dynamometer car ahead. We ran half-way up and got stalled. Well, that is strange. Take off a load, and try it again; we took off thirteen loads before we got that train up. It is evident that there are many things yet to be investigated in railroading.

MR. RHODES: Professor, name the road.

PROF. BRECKENRIDGE: I do not know as I ought to; call it road "E." I thoroughly believe with Mr. Forney that there has been progress in all sorts of things. We used to say that there were two sides to every question. Gentlemen, every question is a polygon. When you say there are only two sides to a question, that is way back twenty-five years. Why, some questions are circles, and every fellow here stands at a different point of view; and every fellow here sees a different side of it, and that is what these clubs are for. Every fellow tells what he sees from his side.

PROF. GOSS: With reference to some of the questions which have been asked, I would say that the purpose of the tests, so far as the laboratory was concerned, was merely to determine the relative value of certain coals. The purpose was not to determine the locomotive performance. This statement will explain why many facts,

which one would expect to see in a study of the latter sort, are absent in the present exhibit. In justice to Mr. Garstang, it should be said also that the paper, as stated by him, is an abstract of a more elaborate statement constituting the report made by our laboratory to him. While some things may appear which are not explained, I certainly think Mr. Garstang has shown great skill in presenting the important facts developed by the tests.

Upon another point I venture to hope that no one will go away from this meeting convinced that locomotives have an appetite for coal of poor quality. This is not the case. Any locomotive will give a higher evaporation with good coal than with poor coal. The fact seems to be, as disclosed by the discussion, that the increase in the evaporative efficiency with increase in the quality of coal, does not keep pace with the increase in cost of the coal. If we could have good coal for the same price as poor coal, there would be no question as to which we would choose.

The fact should be emphasized, also, that the poorest coal tested, the results for which are presented by Mr. Garstang's paper is, from the point of view of those who use western coals, really a coal of good quality.

MR. B. W. THURTELL: These two tests were made by two different firemen, but in order to get exact data it is necessary to have the same fireman with the various kinds of coal. A number of years ago I handled a great deal of coal, and for a number of years I shoveled it into the furnace, and know something about it. The average fireman seems to think that his duty is to get the coal into the furnace, irrespective of what becomes of it after it is in, and the result is a low rate of evaporation; it is too low. When I was an engineer in charge of a large battery of boilers, burning about sixty tons of coal a day, I could not get the fireman I wanted, and I suggested we employ a first-class fireman and pay him more money than we were then paying. The firm said it would bankrupt them to pay a fireman more. After awhile I had to fire myself, and instead of burning sixty tons of coal a day, I burned less than twelve, and instead of the steam dropping from eighty pounds down to forty and thirty, it never varied two pounds. I was simply getting something out of the coal. Now, in all these tests, unless you take into consideration the fireman, the tests are not reliable. The combustion must be complete. In ordinary practice, six pounds

of water evaporated per pound of coal is low, and the ordinary stationary engineer who cannot show better results than that cannot hold his position, and I do not know why locomotive engineers cannot get just as much out of the coal as can the stationary engineer. In order to get the best results out of the coal you must employ a good fireman and keep the grates clean.

MR. RHODES: Just one word in part justification why we do not get the best results out of the locomotives. It is this: In railroad service the main object is not to run locomotives so that they will burn a small quantity of coal, but by far the most essential service is to run engines in such a way that they will get the freight train and the passenger train from one terminal to the other on time. Everything else, in railroad work, is subordinate to this. Once we get our freight and passenger trains from one terminal to another on time, then we can start in and see what changes can be made to do it more economically.

PROF. GOSS: In further explanation of Figs. 3 to 11, inclusive; it is evident that great difficulty is to be encountered in attempting to check experimental results under conditions involving so many chances for variation as must necessarily exist in locomotive work. Certain factors, as speed, steam pressure, etc., can, upon a testing plant, be controlled with a high degree of accuracy, but other things appear, such as the condition of the fire, depending upon the personality of the fireman, the character of the fuel, however carefully sampled, which cannot be depended upon to remain constant.

It should not be a matter of surprise, therefore, that duplicate tests do not give precisely the same results. There is, in fact, a sense in which such tests should not be regarded as duplicates, for the quality of the samples varied greatly in different portions of the car, though it is entirely proper to weigh the evidence presented by each of the two tests, which were run at the several different speeds under which the different samples were tested. To assist in comparing results, important relationships have been plotted. The significance of the lines thus obtained will be understood from the following explanation:

Suppose, as an illustration of the method followed in plotting, that it is desired to study the variation between the *water evaporated per foot of heating surface per hour* and the *water evaporated per pound of coal*. Fig. 12 shows by the centers of the two circles

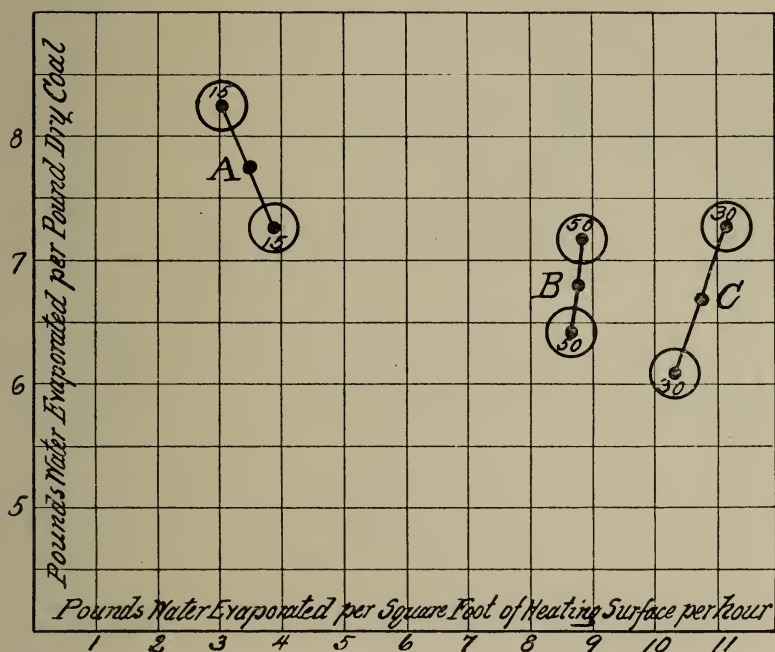


FIG. 12.

bearing the number 15, the location of points representing this relationship for the two 15-mile tests. If equal weight is to be given the results of each test, we may assume that the real point is the mean of the two which are given, that is the point "A," and for all purposes of comparison between the different samples this point "A" should be used instead of either of the actual points obtained.

In a similar manner, the average of the two 30-mile points is the point "B," and the average of the two 50-mile points the point "C" and as before, these points B and C, and not the actual points of the tests are to be accepted as representing the true conditions for the 50-mile and the 30-mile tests respectively.

A careful examination based upon the mean points, such as B and C, will show that differences in effect, due to the changed character of the exhaust, while measurable in some cases, are nevertheless so slight as to warrant the conclusion that all effects, the relations of which are to be studied, are practically proportional to the rate of evaporation. This being true, it seems desirable to average the mean

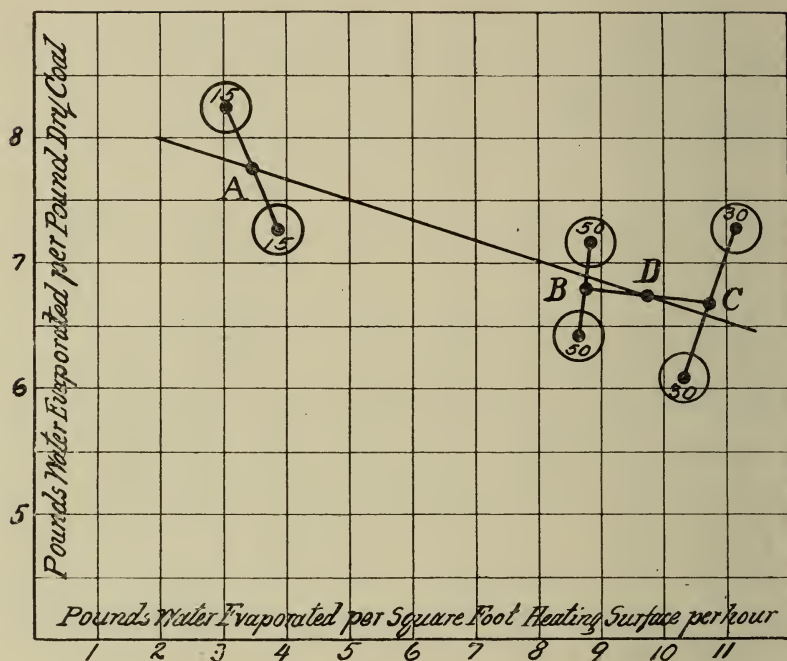


FIG. 13.

results of the 30 and 50-mile tests, which has been done by bisecting a straight line, joining points as B and C, giving the point D (Fig. 13). Finally, connecting by a straight line the points A and D gives a line which shows the relationship under consideration (in the present case the *rate of evaporation and efficiency*) which may be considered the mean of all of the experimental results for a given sample. The line AD, therefore, is the line which is sought. Any experimental point which falls directly upon this line may be assumed to be a true point and, in general, the amount which any point departs from it is to be counted as an irregularity arising from inaccuracies, or from imperfectly controlled conditions.

The discrepancies shown in diagrams Figs. 12 and 13 are exaggerated for the purpose of illustration. Points in the diagrams which have been discussed all lie very near the mean curve.

MR. ETINGER: I wish to say that in making these tests we made every effort to be accurate. We selected a good fireman, probably as good as there was on the road, and run the engine on

the same train, and having the same engineer and same fireman every day. Table VII was not made to show anything except the relative value of the coals tested; it was not made to show the efficiency of locomotives, and any locomotive comparisons made were only to show that the different coals gave the same relative performance on the two different engines. While it is true that we were making locomotive tests at the same time and a portion of the results show in these tables, it was not the intention to submit them as a locomotive test further than that portion bearing on the coal performance.

I will say we have just finished another test of thirty days' duration made during the cold weather of November and December, and the results obtained are not very different from those submitted in this report.

THE PRESIDENT: If there is nothing more to be said on Mr. Garstang's paper, I think we had best proceed to the topical discussion; the subject is so nearly related to that of the paper that it will be, practically, a continuation of the paper.

TOPICAL DISCUSSION.

"What Style of Grate are You Using in Locomotive Fire Boxes when Burning Coal Similar in Quality to Illinois or Iowa Coal?" We would be glad to hear from Mr. Manchester.

MR. MANCHESTER: We are using a rocking grate which does not have fingers. The space between the grates is $\frac{3}{4}$ -inch, and the opening in the grate itself is about $\frac{5}{8}$ -inch. Our 18-inch and 19-inch engines have from 18 to 20 square feet grate surface; I do not know as I can say much more until somebody else stirs up the question.

MR. MARSHALL: Are you using the same grates for the Illinois coal as you are for the Iowa coal?

MR. MANCHESTER: We are. While we have never gone into the matter for a thorough and systematic test, yet it has been our belief that a grate which could be rocked pretty freely and frequently without shaking much into the ash pan except the ashes, was an economical grate, to say the least. Our objection to the finger grate has been that possibly it would allow not only the clinkers, but also some coal, to drop into the ash pan.

THE PRESIDENT: At a meeting of the Board of Directors today,

the report of the Secretary showed that there are about 300 members who are delinquent for dues. If there are any of those 300 here, I hope that they will not forget that the Secretary is present, and one of his duties is to receive the dues.

Adjourned.

The Trustees of the Library wish to acknowledge with thanks the following donations to the Library, received since Oct. 1, 1898 :

Mr. J. W. Cloud, Secretary: Report of Proceedings of the Thirty-Second Annual Convention of the Master Car Builders' Association, held at Saratoga, N. Y., June 15-17, 1898.

Mrs. David L. Barnes: Changes in the Rates of Charge for Railway and Other Transportation Services, by H. T. Newcomb. Pamphlet published by U. S. Department of Agriculture. 1898.

Mr. Charles C. West: Sibley Journal of Engineering for 1898-1899.

Baldwin Locomotive Works: Record of Recent Construction. Nos. 7, 8 and 9. Pamphlets. 1898.

U. S. Department of State: Commercial Relations of the United States with Foreign Countries during the Years 1896 and 1897. In two volumes. 1898.

Prof. Ira O. Baker: The Technograph. Published annually by the Engineering Societies of the University of Illinois. No. 12. 1897-1898.

Mr. W. D. Crosman: Soft Coal Burning, by C. M. Higginson. Fifth edition. 1898. Pamphlet.

Also, 134 copies of back issues of seven different railroad clubs.

Prof. Richard A. Smart: A Handbook of Engineering Laboratory Practice, by Richard Addison Smart, M. E. First edition. New York, 1898.

Mr. Allan F. McIntyre: Handbook on Structural Steel. Cambria Iron Co. 1898.

A. & P. Roberts Co.: Steel in Construction. Tenth edition. 1898.

Mr. William Forsyth: The Science of Railways, by Marshall Monroe Kirkman. 12 volumes. Illustrated. New York and Chicago, 1898.

From the Secretary: Charter, By-Laws and List of Members of the Institution of Civil Engineers (England). Oct. 1, 1898.

From the Secretary: Annuaire and List of Members Societe des Ingenieurs Civils de France. 1898.

Mr. H. H. Miner: The Treatment of Steel. Published by the Crescent Steel Co. Also, Steel Making. 1898.

Mr. W. O. Thompson, Secretary: Proceedings of Sixth Annual Convention Traveling Engineers' Association, Buffalo, Sept. 13-16, 1898.

Messrs. Powell & Colne. The Tropenas Steel Process, by Alexander Tropenas. Detroit, 1898. Pamphlet.

Mr. R. Quayle: Seven copies back issues of the Proceedings of the Western Railway Club.

Bureau of Steam Engineering, Navy Department: Annual Report of the Chief of the Bureau of Steam Engineering. 1898.

Mr. John W. Cloud: Journal of the Association of Engineering Societies, Aug. 1893 to Dec. 1895. Vols. XII to XIV.

Science, Jan. 1889 to June 27, 1890, and Jan. 1, 1895 to June 24, 1898. Vols. II to VII.

Electrical Review 1891 to 1898 inclusive. 8 volumes.

Railroad and Engineering Journal, 1887 and 1888.

American Engineer and Railroad Journal, Jan. 1893 to Dec. 1895. Vols. LXVII to LXIX, inclusive, complete, and from June 1896 to Dec. 1897, inclusive.

Locomotive Engineering, 1896 and 1897.

Reports of Tests of Metals, 1891 and 1892.

Transactions of the Institution of Junior Engineers (England). Vols. IV and V, 1893-94 and 1894-95. Edited by Walter T. Dunn.

Operations of the Division of Military Engineering of the International Congress of Engineers, Columbian Exposition, 1893.

Report of State Board of Health of Connecticut, 1896 and 1897.

Annual Report of the Smithsonian Institution, 1892 and 1894.

Proceedings of the Committee of Locomotive and Carriage Superintendents of India. Vol. II, 1890, to Vol. VI, 1894, inclusive. Five volumes, cloth.

Reprint of Proceedings of same Association. Vols. I-V, 1889-1893. Paper.

Indexes to Vols. I-VI of same. Paper.

General Directory of Railway Lists of same for 1892 and 1894-1896, inclusive. Paper.

Also, General and Subsidiary Rules of same, corrected to Jan. 1, 1894.

Transactions of American Society of Mechanical Engineers. Vol. XVI, 1895, to Vol. XVIII, 1897. Complete. Paper.

Reports of the International Railway Congress, fifth session. London, 1895. Nos. 1 to 12, inclusive, and 29 to 35, inclusive. Two sets.

THE DAVID L. BARNES LIBRARY.

SPECIAL NOTICE! The David L. Barnes Library of this Club, at 1750 The Monadnock, Chicago, is open for the use of members and their friends, and we hope it will be used freely. It is open on week days from 9 a. m. to 5:30 p. m., except on Saturday, until 3 p. m. Books must not be removed from the Library, but the librarian will assist visitors in finding information and will promptly reply to letters from out-of-town members desiring information from the Library. Donations of books and technical publications will be gratefully received.

TRUSTEES OF THE LIBRARY.

List of duplicate copies of the Proceedings of the Western Railway Club which are in the David L. Barnes Library and are for sale or exchange:

1888—Sept. and Oct. (bound in one).

1889—Oct., Dec.

1890—Feb., Sept., Oct., Nov., Dec.

1891—Jan., Mar., Apr., May, Oct., Nov.

1892—Jan., Feb., Apr., May, Sept., Nov., Dec.

1893—Two complete volumes; also single copies of Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

1894—Jan., Mar., Apr., May, Oct., and Index of subjects discussed by the Club.

1895—Jan., Apr., Sept., Oct., Nov., Dec.

1896—One complete volume, also single copies of Jan., Mar., May, Sept., Nov.

1897—Jan., Feb., Mar., Apr., May, Sept., Nov., Dec., also two complete volumes.

1898—Jan., Feb., Mar., Apr., May.

Correspondence relating to the Library, donations of books, periodicals, etc., for the files, or duplicates sent for exchange should be addressed to H. de K. Woods, Librarian, 1750 Monadnock, Chicago.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED, April, 1884.

INCORPORATED, March, 1897

JANUARY 25, 1899.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 5.

CHICAGO, ILL.

\$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Roadmaster, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER.	JOHN W. CLOUD.
F. W. BRAZIER.	H. G. HETZLER.
PETER H. PECK.	F. W. SARGENT
PROF. WM. F. M. GOSS.	

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio.

The regular monthly meeting of the Western Railway Club was called to order at 2 p. m. Tuesday, January 17, 1899, in the Auditorium Hotel, Chicago, Ill. Second Vice-President, Professor Wm. F. M. Goss in the chair.

Following are the names of those who registered:

Allen, F. J.	Giroux, G.	Peck, Peter H.
Anderson, Thos.	Goehrs, Wm. H.	Phillips, Edw. A.
Ball, H. F.	Gohen, J. A.	Rhodes, G. W.
Bischoff, G. A.	Goss, Prof. Wm. F. M.	Rhodes, Wm.
Brown, Angus	Gowing, J. P.	Rielly, B.
Bryant, Geo. H.	Haring, John G.	Royal, Jr. Geo.
Cardwell, J. R.	Haskell, B.	Sanborn, J. G.
Clifford, C. J.	Hawkesworth, D.	Scales, R. P.
Cockfield, Jos.	Hetzler, H. G.	Scott, G. W.
Cooke, W. J.	James, Geo. J.	Simpson, W. M.
Cushing, Geo. W.	Johnson, W. W.	Slater, F.
Delano, F. A.	Keeler, Sanford.	Smith, H. E.
Deibert, F. W.	Kilvert, M. A.	Smith, J. E.
De Remer, W. L.	Kirby, W. S.	Smith, R. D.
Doebler, C. H.	Kirby, T. B.	Soule, R. H.
Eames, Ed. J.	Lane, F. W.	Tratman, E. E. Russell
Elliott, W. H.	Manchester, A. E.	Waitt, A. M.
Fildes, Thos.	Mason, Geo. G.	Whitridge J. C.
Fitzgerald, J. J.	Molleson, Geo. E.	Whyte, F. M.
Furry, Frank W.	Morris, A. D.	Wickhorst, M. H.
Gardner, J. W.	Neely, B. J.	Woods, E. S.
Gasche, F. G.	Noble, L. C.	Younglove, T. G.
Gately, Chas. L.	Otley, Samuel	

THE CHAIRMAN: The President is not with us on account of illness; the First Vice-President has not been heard from, and your Second Vice-President not knowing the state of affairs, came in at the last hour and is here by chance.

The first order of business is the approval of minutes of the December meeting, and it is our custom to approve our minutes as printed, unless there is objection. Is there any objection to such approval? Hearing no objection they stand approved as printed.

The next order of business is announcement of new members.

The Secretary then read the following names:

Mr. W. H. Bradley, President, M. T. & W. Ry., Tomahawk, Wis.

Mr. Elmer E. Cook, Supt., McGuire Mfg. Co., 122 N. Sangamon St., Chicago, Ill.

Mr. W. L. De Remer, Western Agt., National Car Roofing Co., Old Colony Bldg., Chicago, Ill.

Mr. J. J. Fitzgerald, Signal Foreman, C., B. & Q. R. R., Chicago, Ill.

Mr. J. H. Hamilton, Supt., Ohio River R. R., Parkersburg, W. Va.

Mr. Alfred R. Kipp, P., C. C. & St. L. Ry., Indianapolis, Ind.

Mr. C. J. Lindquist, Foreman, Coach Repairs, C., M. & St. P. Ry., Minneapolis, Minn.

Mr. H. D. Page, M. M., C. & N.-W. Ry., Baraboo, Wis.

Mr. Wm. A. Randow, Engineer, D. & R. G. R. R., Denver, Col.

Mr. H. S. Shields, Flood & Conklin Co., 132 Chestnut St., Newark, N. J.

Mr. T. Sullivan, C., & E. R. R., Huntington, Ind.

Mr. J. M. Taylor, Storekeeper, I. C. Ry., Burnside, Chicago, Ill.

THE CHAIRMAN: We have a committee on specifications; is there a report from this committee?

THE SECRETARY: The chairman of the committee on specifications reported to me a day or two ago that they desired to report progress at this meeting, and hope to make the final report either in February or in March. A number of the specifications have been prepared and others are in the course of preparation.

THE CHAIRMAN: Can the Secretary make a report concerning the excursion which starts to-night on a visit to the Niles Tool Works Co.?

THE SECRETARY: The Secretary was instructed to co-operate with Mr. Geo. F. Mills, of the Niles Tool Works Company in arranging for the excursion. Postal cards were sent out asking for replies from those who would go, and about 150 replied in the affirmative. Since the replies were sent, however, some have found it impossible to go. The arrangements have been completed and the number will be large enough to require about five sleeping cars. These are supplied by the Niles Tool Works, and Mr. Mills will be at the gate this evening, between 8 and 8.30 o'clock to pass in those who are going on the excursion and furnish the transportation there. The train leaves at 8.30 and will be side-tracked at the Niles Tool Works in the morning. We will spend the day at the Niles Tool Works, returning the next evening.

THE CHAIRMAN: If there is nothing further, we will pass on to new business. What is the new business?

THE SECRETARY: There is a report from the Directors.

THE CHAIRMAN: There is a matter with reference to the publication of the Proceedings which has been under consideration by the Board of Directors, and the President and Secretary were appointed a sub-committee of the board to look into the matter and to report upon

the same. I understand that the Directors have not yet received the report of this sub-committee, and yet the matter is in such shape that the Secretary had best make the statement to you concerning the facts.

THE SECRETARY: The reports of the Proceedings of the Club are becoming more valuable each year, and while some members have complete sets of the Proceedings bound and in shape for ready reference, there are many others who do not have them bound but who appreciate the value of them, and who would have them bound were it not quite so much trouble, and if it were possible for them to find the complete set at the end of each year. It has always been the policy of the officers of the Club to expend the income in such a way as to benefit all the members, and the annual banquet was not favored this year because it was believed that only a small percentage of the membership would benefit by it. Conforming with this policy the Club has, this year, assumed the expenses of the library so well started by the generosity of the late Mr. D. L. Barnes, and it is hoped that every member will profit by the privileges of the library. The Club is furnishing to such of the members who desire them, and who are in good standing, the Proceedings of other railway clubs, and this is done at considerable expense. It is believed that the Club can take another step in advance and one which will be appreciated by every member. This is to give to each member at the close of the club year, the Proceedings of the year substantially bound in one volume. There will be considerable expense attached to this and the officers think that the privilege should not be extended to those whose dues remain unpaid at the close of the year. It costs considerable to collect the dues, and the prospects of obtaining the bound volume should be another incentive for prompt payment. It costs considerable also to inform delinquent members why they are not receiving the Proceedings of this Club or of other clubs.

The advertisers have been very liberal towards the Club and they will benefit by having the same space in the permanent volume as in each monthly issue and without additional cost to them. This will not detract from the appearance of the book.

THE CHAIRMAN: You have heard the statement; is there anything to be said concerning it? I suppose it requires no action on the part of this body, it being a matter entirely in the hands of the Directors. If there is any suggestion, however, or criticism, or anything in commendation, we will listen.

MR. F. A. DELANO (C., B. & Q. R. R.): I think the idea of the Directors is an excellent one. I would like to make one further suggestion, and that is, that an index, or table of contents of papers be arranged for the volume.

THE CHAIRMAN: Do you refer, Mr. Delano, to an index of a single volume, or past volumes?

MR. DELANO: I think each volume ought to have an index of that volume, that is what the engineering societies do, and once in a certain number of years they get up a general index, which is supposed to be an index for a number of years.

THE CHAIRMAN: The understanding is that the Directors have already provided for this. Also that this volume shall be done in the same style and size as the Proceedings of the Master Car Builders' and Master Mechanics' Associations. I think that the Club will find its case well taken care of when the volume is published.

It has been suggested that at this meeting there should be appointed our usual committee to make recommendations concerning the Rules of Interchange. Has the meeting any wish to express with reference to that subject? Shall such a committee be appointed?

MR. G. W. RHODES (C., B. & Q. R. R.): I move that the Chair appoint a committee of five, the committee to be representative by including switching roads and private car lines, to review the M. C. B. Rules of Interchange, and to report to the Club such changes in the rules as may seem advisable for the Club to recommend to the Master Car Builders' Association.

THE CHAIRMAN: As many as are in favor of appointing such committee of five, and in the manner described, will please manifest it by saying aye. (Carried.)

The Chair will name as such committee, Mr. J. N. Barr, Chairman; Mr. Thomas Fildes, Mr. R. D. Smith, Mr. T. W. Kirby and Mr. Peter H. Peck.

The next order of business is the presentation of the paper:

TESTS OF LOCOMOTIVE BOILER COVERINGS.

BY MR. ROBERT QUAYLE.

1.—The extent of heat losses occurring by radiation from a modern locomotive boiler under service conditions, has long been a matter of speculation. There have been investigations to determine the radiation from pipes and other steam-heated surfaces, usually within buildings, but until recently, there have been no tests which would disclose the effect of the air currents such as, at speed, circulate about the boiler of a locomotive.

The tests herein described were undertaken by the Chicago & North-Western Railway Company, in co-operation with several manufacturers of boiler coverings. The work was in the general charge of Mr. Waldo H. Marshall, assisted by Mr. F. M. Whyte, both of the North-Western road. Representatives of the several manufacturers interested attended the tests and the manufacturers were also represented by Professor Wm. F. M. Goss, who, by the mutual arrangement of all parties, assumed control of the data as taken. It was agreed that one report should be formulated, and that duplicate copies of this should be delivered to all parties concerned in the work. The facts presented in this paper, are, therefore, abstracted and arranged from Professor Goss' report.

In formulating this paper it has been thought wise to first present a brief summary of methods and results, leaving all discussion of details a place in an appendix.

2.—*Plan of the Tests.*—In carrying out the tests two locomotives were employed; one to be hereafter referred to as the "experimental locomotive" was subject to the varying conditions of the tests; the other was at all times under normal conditions, serving to give motion to the experimental locomotive, and as a source of supply from which steam could be drawn for use in maintaining the experimental boiler at the desired temperature. The experimental locomotive was coupled ahead of the normal engine, and, consequently, was first when running, to enter the undisturbed air. The action of the air currents upon it, therefore, was in every way similar to those affecting an engine doing ordinary work at the head of a train.

The boiler of the experimental locomotive was kept under a steam pressure of 150 pounds by a supply of steam drawn from the boiler of the normal engine

in the rear. There was no fire in the experimental boiler. It was at all times practically void of water. Precautions were taken which justified the assumption that all water of condensation collecting in the experimental boiler was the result of radiation of heat from its exterior surface. This water of condensation was collected and weighed, thus serving as a means from which to calculate the amount of heat radiated. The head of the experimental train is shown by Fig. 1:

3.—*The Experimental Boiler.*—The Chicago and North-Western locomotive, No. 626, the boiler of which served in the experiments, is of the 8-wheeled type, weighing about 90,000 pounds. An outline drawing, used in ordering covering, is shown by Fig. 2. The principal dimensions of the boiler are as follows:

TABLE I.

Dimensions of boiler.

Diameter in inches.....	52.
Heating surface (square feet).....	1,391.
Total area of exterior surface, not including surface of smoke-box.....	358.
Area of surface covered (square feet).....	219.
Area of steam heated exposed surface not covered.....	139.
Ratio of surface covered to total surface.....	.61

It should be noted that the values given in Table I are based upon projected areas of the plain boiler. No account has been made of the edges of plates at joints, or of surface due to the projection of rivet heads, or to the surface of various attached projections, such as running-board brackets and frame fastenings. While all such projections above the general surface of the boiler are active agents in conducting heat from the interior, the present study does not require them to be taken into account. The extent of area covered for this



FIG. 1.

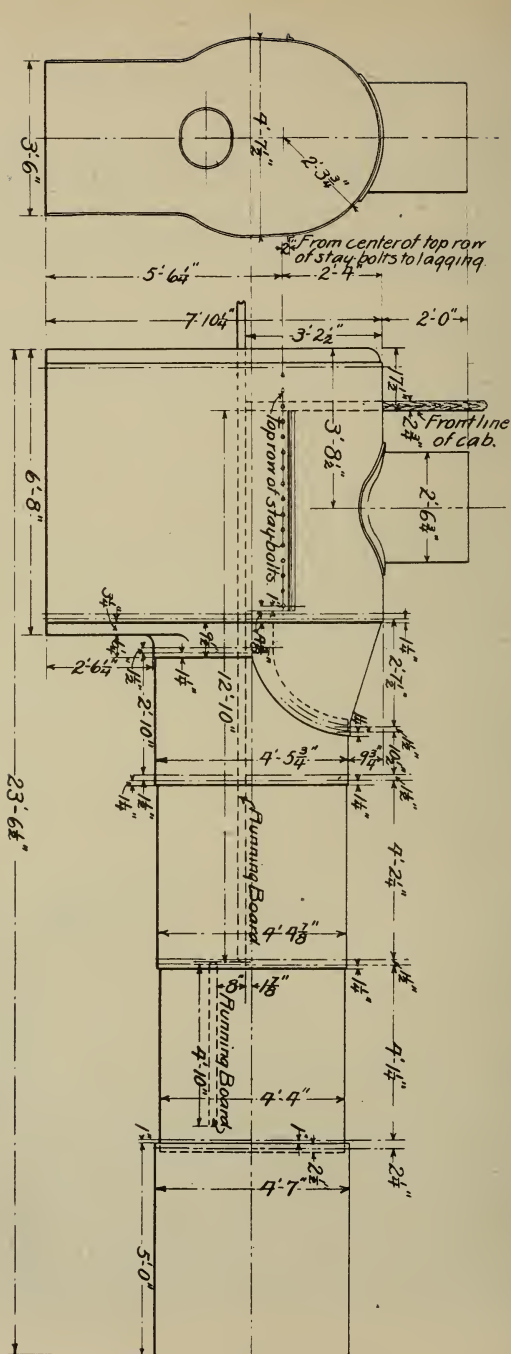


FIG. 2.

boiler is entirely normal for the class of locomotives to which No. 626 belongs, which gives added interest to the fact that but 61 per cent. of the exposed surface of the boiler was covered.

4.—*The Tests* made were of two sorts: First, with the experimental engine at rest, which test will be hereafter referred to as the "standing test;" and the second, with the experimental boiler in motion at a rate of speed, approximately, 28.3 miles per hour, to be hereafter referred to as the "running test." Both standing and running tests were made with the experimental boiler bare, and also when protected by six different coverings. Tests of two of these were repeated, making altogether nine standing tests and nine running tests to be reported. These are designated as follows: A, B, C, D₁, D₂, E, F₁, F₂, and G. "A" represents the test of the bare boiler. "D₁" and "D₂" are different tests of the same covering, and, similarly, "F₁" and "F₂" are tests of a single covering.

5.—*Results.*—The observed and calculated results are given in detail in Tables VI and VII of the appendix. A summary of these is here given as Table II.

TABLE II.
Pounds of steam condensation per minute.

	A (Bare Boiler)	B	C	D ₁	D ₂	E	F ₁	F ₂	G
Standing test.	6 78	2.63	3 42	2 91	2.80	3.52	3.04	3.22	3.03
Running test. Speed, 28.3 miles.	14.27	5.68	5.47	5.03	5.34	5.21	5.29	5.30	5.70

The values, as given, have been reduced to a common basis with reference to steam pressure, atmospheric temperature, and running speed, and so far as these factors are concerned, are comparable. They have not been corrected for variations in thickness of covering which, in all cases, was slight, or for variations in the velocity and direction of the wind.*

6.—*Efficiency of Coverings.*—The percentage of the heat transmitted from the bare boiler, which is saved by any covering, may be obtained by subtracting the amount of condensation for the covering in question from the condensation for the bare boiler, and by dividing one hundred times this difference by the condensation for the bare boiler. The result expresses the efficiency of the covering. Values thus obtained are given in Table III:

TABLE III.
Efficiency of coverings as disclosed by running tests (per cent).

B	60.2
C	61.7
D ₁	64.8
D ₂	62.6
E	63.5
F ₁	62.9
F ₂	62.8
G	60.1

* See Appendix.

The results appearing in this table are corrected for variations in steam pressure, atmospheric temperature and speed, but not for variations in weather and wind conditions or for variations in thickness of covering. The average efficiency disclosed by the eight tests is 62.3 per cent. The greatest variation from this average is that for test D_F, which represents a 3 per cent. higher efficiency.

The results for tests B and G are practically identical, both giving an efficiency of 60 per cent., the lowest value appearing in the series, but only 2 per cent. below the average of all. The result for test D₁, compared with the others, is high. Omitting these three tests, the remaining five (C, D₂, E, F₁, and F₂) give results which in no case vary from the average of the five by an amount greater than 1 per cent.

The conclusion, stated in very general terms, is that any of the coverings tested can be relied upon to save from 60 to 64 per cent. of all the heat which would radiate from the boiler were it not covered at all. A fairly representative result may be stated as 62.3 per cent.

7.—*Comparison of Results.*—It should be continually borne in mind that it was not proposed to measure with scientific accuracy the non-conducting properties of covering materials, but to show the value of laggings made up of various materials, and in various forms, when subjected to the conditions of locomotive service. The purpose sought has been attained. The work has been conducted upon an unprecedented scale, and the extent of such losses has for the first time been fully disclosed. But service conditions which were necessary to the general demonstration could not always give similar conditions for different tests, though it is believed that no single test was affected by variations of conditions, by more than 2 or 3 per cent., an amount which would seem to be entirely negligible. Such a variation in results would be negligible if the efficiency of a single covering only were involved, or if, where several are involved, the results for each of the several coverings were widely different. In the present case the results for the different coverings are so nearly the same that if those for one covering were increased by 2 per cent., and those of another diminished by the same amount, the relative position of the two coverings might be completely reversed. It is important, therefore, to emphasize the fact, that the relative standing of any two coverings, as disclosed by the results here given, is not to be relied upon when the difference between them is small.

In this connection it should be noted that for comparative purposes the results of the running tests are more reliable than those from the standing tests.

8.—*One Reason for Similarity of Results.*—The fact that the results obtained from the several coverings are so nearly alike can hardly fail to occasion surprise. Had thin layers of the material tested been subjected to carefully planned laboratory tests, the results would doubtless have differed more widely, but it must be expected that the value of such difference will diminish as the specimens experimented upon are increased in thickness. A material which is rather an indifferent non-conductor will serve to prevent the passage of heat if applied in sufficient thickness. While, therefore, the coverings tested were of normal thickness, it would seem that this thickness is sufficient to reduce to a negligible

amount the effect of the superior non-conducting properties which the material of one covering may have possessed over others.

9.—*Efficiency of Covering and Different Portions of the Boiler.*—The results show that the covering of 61 per cent. of the exterior surface of the experimental boiler saves 62.3 per cent. of all the heat radiated from the same boiler under similar circumstances, when bare. It does not, however, follow from this statement that if 100 per cent. of the exposed surface of the boiler were covered, 102 per cent. of the heat lost from the bare boiler would be saved. Such a conclusion must obviously be absurd, though a hasty consideration of the facts presented might seem to justify it. The fact, as first stated, however, proves that there is a vast difference in the character of the exposure to which different portions of the boiler are subjected. While only 61 per cent. of the surface of the boiler was covered, the protection was evidently applied where it was most needed. The percentage of the *total exposure* guarded against was greater than the percentage of surface covered. For this reason, increasing the covered area by 10 per cent. cannot be depended upon as a means of reducing radiation losses by a like amount. It will reduce loss, but the amount of the reduction may be very much less than 10 per cent. It is for this reason, also, that all comparisons in this report have been based upon the boiler as a whole. The radiation is stated in terms of pounds of steam condensed per minute for the boiler experimented upon, rather than as pounds per minute per square foot of exposed surface. The latter unit would be a more general unit, but its use in interpreting the data under consideration would be misleading.

10.—*Radiation and Its Power Equivalent.*—Assuming that a locomotive will develop a horse power by a consumption of twenty-six pounds of steam per hour, and assuming that the steam thus consumed must be generated from water at 80 degrees F., the radiation losses already given may be expressed in terms of power losses of equal value. The practical effect of these assumptions is to define a horse power as equal the condensation under the conditions of the tests of thirty-four pounds of steam per hour, the steam having a pressure of 150 pounds and the water the temperature due to this pressure. Upon this basis the following results are obtained. They apply only to the boiler tested:

TABLE IV.
Power lost by radiation.

	Horse-Power Equivalent to Radiation Losses.
<i>Bare Boiler:</i>	
Locomotive at rest, under conditions of test.	12.
Locomotive running 28.3 miles per hour and otherwise under conditions of test.	25.
<i>Covered Boiler:</i>	
Locomotive at rest under conditions of test.	4.5
Locomotive running 28.3 miles per hour and otherwise under conditions of test.	9.

A locomotive similar with that tested may be expected to deliver a maximum of 600 horse power. It is evident that if the uncovered boiler were under conditions of speed, etc., which are not now uncommon in service, that at least

10 per cent of the total power of the machine would be lost in radiation from its exterior surface. This, then, discloses the extent to which locomotive performance may be affected by radiation. A perfect covering enveloping the entire external surface of the boiler would prevent the entire loss. Actual coverings, such as those tested, extending over a portion of the surface, prevent approximately 62.3 per cent of the loss. It seems to be a fact, therefore, that a boiler protected in accord with good practice loses power when standing in warm weather, at the rate of four and a half horse power, which amount will increase if the pressure of steam is increased, or the temperature of the atmosphere is reduced, or the engine is put in motion.

11.—*Cost of Radiation* from the boiler experimented upon may be stated as follows:

TABLE V.
Bare boiler.

Pounds of coal per hour equivalent to radiation losses, assuming evaporation from and at 212 deg. F., of six pounds of water per pound of coal—	
When standing.....	60.
When running 28.3 miles per hour.....	126.
Tons of coal per month, assuming boiler to be under steam standing 200 hours and running 28.3 miles per hour during 300 hours per month.....	25.
Cost of radiation per year for the boiler tested, assuming the conditions of the preceding paragraph and assuming the price of coal \$2.00 per ton.....	\$600

As locomotives are never run entirely bare, the estimated annual loss by radiation, of \$600 per engine, is higher than would be likely to occur on any engine in service. It is, however, a statement of the total loss which may occur, and as such will be useful in estimating the value of savings which may be effected by the application of coverings.

It has been shown that the several coverings tested have an efficiency which is not far from 62.3 per cent. The annual saving, therefore, which would be effected by the application of any of the coverings would be

$$\$600 \times .623 = \$383.80,$$

the remaining \$226.20 still going to waste through radiation. The results show that anything which will increase the efficiency of the covering on the engine tested by 1 per cent. will result in a saving of \$6.00 per annum. A 2 per cent. increase of efficiency will save \$12.00, a 3 per cent. increase \$18.00, and so on. This holds for the particular engine tested and for the conditions under which the engine was tested.

12 — *The Fact* should be emphasized that the results thus far given are those derived from the actual experiments. These involved a boiler of moderate size, carrying steam pressure which is now regarded as low, and were conducted in the month of August. It should be noted, also, that the running tests involved a speed of less than thirty miles per hour. It is evident that other con-

ditions, quite common to actual service, would operate to greatly increase the radiation losses described. The effect of changes in some of these conditions will next be considered.

13.—*The Effect of Changes in Speed on Radiation* has long been an open question. It has been argued that a boiler perfectly covered would be, to a very great extent, unaffected by surrounding air currents, and hence that its radiation losses would not be materially greater when the locomotive is at speed than when standing. But those who appreciate the intensity of the cooling currents,

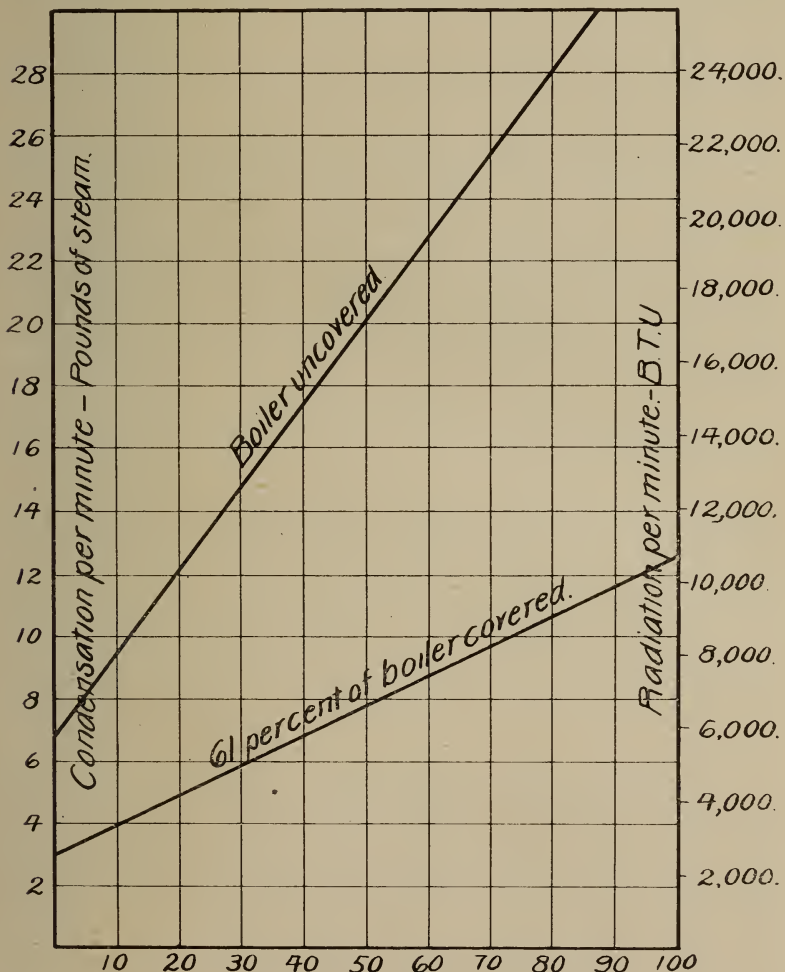


FIG. 3.

which circulate about a locomotive when at speed, have been slow to accept such a view, and the tests under consideration confirm their position. They give a measure of the radiation losses, both when the locomotive is at rest and when moving at a uniform speed of 28.3 miles an hour. While these points are not sufficient to establish with accuracy the complete relationship of radiation and speed, an estimate of real value may be based upon them. Such an estimate is presented in the form of a diagram, Fig. 3.

The diagram shows that the bare boiler, when at rest, radiates sufficient heat to condense 6.78 pounds of steam, at 150 pounds pressure, per minute, which amount is increased to twenty-eight pounds when the same boiler is driven at a speed of eighty miles an hour.

Similar values for the covered boiler are 3.0 pounds and 10.6 pounds respectively.

14 — *Changes in Atmospheric Temperature.*—The results recorded were obtained in mid-summer and all have been corrected for an atmospheric temperature of 80 deg. F. For each 10 deg. reduction in atmospheric temperature below 80 degrees, the radiation may be expected to increase 3.5 per cent. For zero degrees temperature the radiation losses recorded in this report should be increased by about 28 per cent. For example, if, when the atmospheric temperature is 80 deg. the conditions are such as result in the condensation of five pounds of steam per minute; when the atmospheric temperature is 0 degrees the condensation will be

$$5 + 5 (.035 \times 80) = 5 + 1.4 = 6.4$$

From this it appears that very low temperatures are attended by radiation losses of considerable magnitude.

15.—*Changes in Steam Pressure.*—The experiments were conducted under a boiler pressure of 150 pounds by gauge. With an increase of pressure the boiler temperature will become higher, and the radiation losses will, as a consequence, be augmented. Changes arising from this source, however, are not great. For each ten pound increase of pressure above the limit of 150 pounds the radiation may be expected to increase by about 1.6 per cent., but this will not apply for pressures much above 200 pounds. A pressure of 200 pounds will involve losses by radiation which are 8 per cent. greater than those making up the record of this report.

16.—*Possible Losses from the Boiler Experimented Upon.*—Applying the results expressed in the preceding paragraphs, it can be shown that with the boiler bare and the locomotive running at eighty miles an hour, under a steam pressure of 200 pounds, with the atmospheric temperature 0 degrees, the loss by radiation would be the equivalent of sixty-seven horse-power, while a covered boiler running under the same conditions of speed, pressure, and atmospheric temperature, would still be subject to a loss of twenty-five horse-power. As a locomotive similar to that tested may be expected to deliver a maximum of 600 horse-power, it is evident that under the extreme conditions just assumed, which are not at all uncommon to service, at least 10 per cent. of the total power

of the engine would be lost in radiation. This is for an uncovered boiler. An application of any of the coverings tested would reduce the loss to about 4 per cent.

17.—*Size of Boiler.*—In reviewing the facts presented in the preceding paragraphs, it will be well to keep in mind the fact that the boiler tested was one of moderate size. Many boilers are now running which present an exposed area which is at least 50 per cent. greater than that presented by the boiler under test, and it should be evident that the losses from such large boilers will be greater than those disclosed by the tests under consideration. For boilers of the same general type the loss will probably be proportional to the exposed surface.

18.—*Conclusions.*—In view of the very strong air currents which circulate about the boiler of a locomotive at speed it is not surprising that the losses by radiation are large. While their value is dependent upon conditions which may vary widely, they always go on whenever the boiler is under steam. In this respect radiation losses are unlike those which occur within the engines of the locomotive, since, to a considerable extent, these latter cease to operate whenever the throttle is closed.

All of the experimental results and the conclusions based upon them were obtained from an engine of moderate size, carrying a pressure which, in the light of modern practice, must be considered low, and under conditions of summer atmosphere. The running speed, also, was not high. These conditions cannot be considered as in any way calculated to disclose large radiation losses, and yet the results are such as will merit the earnest attention of all who are interested in improving locomotive performance. In this connection it will be well to again emphasize the fact that the losses which have been measured and which are defined in this report do not include radiation from saddles and cylinders, or from any portion of the locomotive excepting the boiler itself.

It may be assumed that the boiler as covered in each of the several tests involving covering, was as well protected against radiation as is the average boiler of American locomotives, notwithstanding the fact that when thus covered there is still a loss of heat, which in money value annually represents many times the cost of the best covering which the market to-day affords. Improvement is to be found not only in improving the character of the covering itself, but chiefly, probably, in extending the covered area of the boiler and projections attached thereto.

APPENDIX.

The following detailed account of methods employed and results obtained will disclose to those interested in following such matters, the justification for the general conclusions which have already been presented in the body of the paper.

The boiler of the experimental locomotive was kept under a steam pressure of 150 pounds by means of a pipe connecting with the boiler of the normal engine in the rear. There was no fire in the experimental boiler and it was at

all times practically empty of water. The whole grate of the experimental boiler was deadened by brick work and as a further insurance against the movement of air currents through the fire box, tubes, etc., the top of the stack was securely filled with wood. The furnace and front-end doors were also carefully closed and fastened. A Cochran steam separator in the supply pipe within the cab of the experimental boiler was assumed to deliver to it steam of a uniform quality. These and other precautions justify the assumption that all condensation occurring in the boiler was due to radiation from its exterior surface.

As a safeguard against air pockets and to further insure a uniform temperature of all portions of the interior of the boiler, steam was allowed to waste from it through a small orifice at the end of a pipe connecting with the front end, and leading outside to the top of the stack, and some leak was allowed also at the whistle valve. The loss of steam from the experimental boiler in no way affected the value of the measurements made, since they neither increased nor diminished the amount of condensation taking place within the boiler.

A 12-inch water glass was attached to the water leg of the boiler close to the mud-ring. A thread around this glass served as a reference line. The water condensing within the experimental boiler was led through a $\frac{3}{4}$ -inch pipe from the blow-off cock at the bottom of the boiler, to a valve at the rear of the cab, thence to the top of the tender tank, at which point it connected with a coil submerged in the water of the tank. The discharge from this coil was delivered to a weighing barrel set up within the coal space of the tender. By these means the water of condensation was made a measure of the amount of heat radiated, its level was maintained constant, and a few inches above the level of the mud-ring, the excess was drained out, cooled to avoid all chance of loss from vaporization, and weighed.

As the scales could not be balanced during a run, and as the weighing tank was of insufficient capacity to hold all of the water accumulating during a test, a calibrated small-necked can was used between stops to reduce the level of the water in the barrel. Each can, as emptied, was charged against the barrel, each full can counting 45.7 pounds.

II. — *Observers.* — Three observers were ordinarily employed during each test. One was assigned the duty of observing the force and direction of the wind, the character of the weather, and to so manipulate the valve in the pipe through which the condensed steam was discharged to the weighing barrel, that the water level within the experimental boiler would at all times remain near the reference line. Another weighed the condensed steam, and a third recorded five-minute readings of the steam pressure within the experimental boiler, and attended to the discharge drain of the steam separator, in order that the water level within this apparatus might be kept within fixed limits. He also rang the locomotive bell for crossings. The referee, while always on the experimental locomotive, had no fixed duties. Cushioned seats were arranged across the rear of the tender for the accommodation of representatives of the various coverings tested. The rear engine carried its usual crew. The train conductor also rode on the rear engine.

III.—*The Track* used for the running tests is a single line extending from Clinton, Iowa, to Anamosa, a distance of seventy-two miles. This stretch of road was chosen because of the light traffic upon it, and the assurance against interruption which this condition gave. It leads over rolling country, and throughout its length is rather sinuous. For the first twenty-five or thirty miles the general direction is northwesternly, and for the remainder of the distance nearly west. For four miles out of Clinton it extends through the yards of that city and the adjoining city of Lyons, and for several miles it follows along the Mississippi River from which it finally leads out upon a more open country. The wind and temperature conditions were generally different for that portion of the road along the river than for portions extending across the more open country. Crossing stops were necessary just beyond Lyons and at Delmar, thirty-three miles from Clinton. There are fifteen stations intermediate between terminals, but with one exception, the plan of the tests did not involve them.

IV.—*Movement During the Tests.*—The work in connection with each covering occupied, ordinarily, a single day. A test under conditions of rest, hereafter referred to as the "standing test" was first made, followed by a test on the road, hereafter to be referred to as the "running test."

Each running test involved a trip from Clinton to Anamosa and return, with an intermediate stop each way at the station of Maquoketa, thirty-eight miles from Clinton and thirty-four miles from Anamosa. By means of these stops it was possible to divide each running test into four parts of nearly equal length, which not only gave opportunity for ascertaining something of the character of the results, which were being obtained, but served as a safeguard against the loss of a whole test in case of an accident on the road. For convenience, these parts of the running tests are hereafter referred to as "quarters," but they are not of equal value. The quarters may be defined as follows:

1st quarter, Clinton to Maquoketa, 38 miles, approximate running time, 83 minutes.

2d quarter, Maquoketa to Anamosa, 34 miles, approximate running time, 68 minutes.

3d quarter, Anamosa to Maquoketa, 34 miles, approximate running time, 71 minutes.

4th quarter, Maquoketa to Clinton, 38 miles, approximate running time, 84 minutes.

In anticipation of a test, the locomotives were coupled, the pipe connections made, and steam turned on the experimental boiler at as early an hour as practicable. In most cases this was between 6 and 7 o'clock in the morning. After the normal pressure had been secured in the experimental boiler, the cooling coil within the tender was put under pressure and examined for leaks. The engines were then moved to the yard stand-pipe and the tender tanks of both engines filled. As soon as practicable after this, and to insure the same level of the experimental boiler for all tests, the engines were moved to a point lower down in the yard where the rear driver of the experimental engine rested over a certain marked tie. The water within the experi-

mental boiler, resulting from condensation, was then brought to the reference line, time was taken, and the scales of the weighing barrel balanced. At fifteen minute intervals thereafter, this process of bringing the water to line and balancing the scales was repeated, usually for a period of from one to two hours, the locomotive remaining in its place upon the marked tie. When the rate of condensation became uniform the standing test was assumed to have commenced.

In due time, usually at about 9:35 in the morning, the water was brought to line for the last observation of the standing test, the scales balanced, and as soon as practicable thereafter the engines were started for the running test. The time of this balancing of the weighing tanks marked the end of the standing test and the beginning of the running test.

The first few miles were, necessarily, at varying speed, but after passing Lyons and the crossing just beyond, a speed of thirty miles an hour was soon secured, and was thereafter maintained until Maquoketa was reached. In all tests the stop at Maquoketa was made with the rear tender under the spout of the water tank, and water was taken by the pushing engine, and the engines were oiled. While this was being done the water of condensation in the experimental boiler was brought to line and the weighing barrel balanced, thus ending the first quarter and beginning the second quarter of the running test. After a ten minutes' stop, start was again made and the run continued to Anamosa, where the stop was made with the rear driver of the experimental locomotive on a certain marked tie. As soon as practicable thereafter the water was brought to line and the weighing barrel balanced, thus ending the second quarter of the test.

At Anamosa the engines were uncoupled and turned one at a time, coupled again, and the rear driver of the experimental boiler brought over the same marked tie upon which stop had been made. Steam was then turned on the experimental boiler and the pressure, which, during the process of turning, usually dropped to about eighty pounds, was restored to normal conditions. The start from Anamosa was made at about 1:45, or an hour and a half after the scheduled time of arriving. This interval gave time for the work of balancing the weighing barrel, turning the engines, and for dinner; it also gave a sufficient period, after normal pressure had been restored in the experimental boiler, to allow everything to become thoroughly warm before starting.

When all was ready the condensed steam in the boiler was brought to line, the weighing tank balanced, and the third quarter of the test thus commenced. As soon as practicable, after the balancing, the train was started on the run to Maquoketa where, as before, the stop of ten minutes' duration was at the water tank. Here, again, the water was brought to line and the weighing tank balanced, thus ending the third quarter and beginning the fourth quarter of the test, and which in turn ended at Clinton at about 4:30 in the afternoon upon the same marked tie from which the engines had been started in the morning.

This process was persisted in with regularity, the intent being to secure similar conditions for each of the several tests.

After the final balance, the tank valves of the experimental locomotive

were opened and the tank drained to allow the inspection of the cooling coil, which inspection, as already stated, preceded every test. Steam was shut off the boiler and the experimental locomotive was pushed into the roundhouse where men were in waiting to strip it of its jacket and covering. Early in the evening work was commenced in applying the covering which was to be tested on the following day, and was continued into the night until finished.

It was found impossible to make the running time of all tests the same. Conditions arose which could not have been anticipated. There were occasional stops due to section gangs and to the presence of other trains. Time which was lost in this way was not made up during the running, the effort being to keep the *speed while running constant*. It is to be noted also that the running tests actually commenced before the train was started, that the ten minute stop at Maquoketa was a part of the running time, and that the test did not end the moment the engine stopped, that is, there was a certain amount of dead time on all running tests. The facts in detail with reference to this are fully presented in another place.

V.—*A Survey of Conditions Affecting Results*.—As an aid to a true estimate of the value of results derived from methods already outlined, it will be well to call attention to the following facts:

- (a) The same boiler was used in all tests.
- (b) The extent of surface covered by each covering tested was the same.
- (c) The thickness of the various coverings tested was intended to be the same, but was not so in fact. Variations in this respect, however, were not great. No attempt has been made to reduce results to equivalent results which might have been obtained had the thickness been the same, but when comparisons are made the facts with reference to thickness are made to appear.
- (d) The measure of heat radiated under the conditions of each test, was determined with great accuracy, the probable error in the running tests not exceeding one in 300, or one-third of 1 per cent.
- (e) Variations in atmospheric temperature were carefully observed and corrections have been applied which reduce all results to equivalent results which would have been obtained had the temperature for all tests been the same. Variations in steam pressure have in like manner been accounted for. The character of these corrections make their application entirely safe.
- (f) No allowances have been made for changes in atmospheric humidity. The facts, however, stated in general terms are given. No tests were made during rain.
- (g) Wind effects probably constitute the most serious disturbing element. The results show that the radiation at a speed of thirty miles an hour was more than double that when the engine was standing. A head wind would have the same effect as an increase of speed in still air, and a wind from the rear, the same effect as a decrease of speed in still air. If, however, the force and direction of the wind remained constant during an entire round trip the increased radiation resulting from going against it when moving in one direction, would be wholly or in part neutralized by the reduced radiation resulting from moving with it on the return trip. The neutralization would be complete if the direction of the wind was in line with the motion of the train, otherwise it would be partial.

As a matter of fact, the direction of the wind was fairly constant for all tests save two, and its velocity was at all times low. The maximum is estimated at between ten and eighteen miles an hour which, compared with the speed of the train (thirty miles), is extremely low.

(h) The purpose of the experiments was not to give results which, as scientific data, would possess a high degree of accuracy, but to give a commercial measure of the radiation losses from a locomotive boiler under conditions of service.

(i) The chief value of the results is to be found in the general conclusions which they may sustain. They are less useful as a means for determining the non-conducting properties of the materials making up the several samples tested.










VI.—*Tests Run*.—In all, ten tests were made. The first, a preliminary run for the purpose of proving apparatus, was with the locomotive as it came from the road. As a result of this run, certain details of the apparatus and the fixed running schedule, afterwards employed, was adopted. Because of these changes in practice the data obtained is not included in that presented.

Concerning the repeated tests, it should be said that upon removing the jacket after the close of the first test in each of these cases, some moisture was found both in the interior surface of the jacket and on the exterior layers of certain portions of the covering. In view of this fact it was thought wise, in both cases, to repeat the test. Both the results of the repeated tests and the fact that evidence of moisture was found upon removing the jacket after several of the tests, indicate that many of the coverings are more or less hygroscopic, and that the accidental moisture in them was driven to the outer layers of the covering and to the jacket. The evidence is that the moisture soon located itself so far away from the heating surface of the boiler that it had no measurable effect on the efficiency of the covering.

VII.—*Thickness of Coverings*.—The practice of covering the surface of a locomotive boiler, with its inequalities, with material in such thickness as will give a smooth exterior surface leads to variations in the thickness of the covering. In the boiler tested the dome casing was so small as to allow only a thin layer (from $\frac{1}{2}$ to $\frac{3}{4}$ -in.) on the barrel. On other portions of the boiler it was intended that the thickness should vary from $1\frac{3}{4}$ -in. on the first ring to $1\frac{1}{4}$ -in. on the slope sheet. An effort was made to have the thickness of all coverings tested the same, and except in two cases this result was very nearly attained.

As a comparative figure, an average thickness of all coverings was obtained by finding the volume of the material used, and dividing this by the area of the surface covered. This process gives the thickness which the material would have had if it had been distributed uniformly over the surface covered. Values thus obtained are as follows:

Covering B.....	1.34 in.=1 $\frac{1}{2}$ in.
“ C.....	1.49 in.=1 $\frac{1}{2}$ in.
“ D ₁	1.45 in.=1 $\frac{1}{2}$ in.
“ D ₂	1.57 in.=1 $\frac{1}{2}$ in.
“ E.....	1.28 in.=1 $\frac{1}{2}$ in.
“ F ₁ and F.....	1.56 in.=1 $\frac{1}{2}$ in.
“ G.....	1.49 in.=1 $\frac{1}{2}$ in.

1	Designation of Test.	BASE BOILER	B	C	D ₁	D ₂	E	F ₁	F ₂	G
2	Date-Month & Day, '98	Aug 11	Aug 10	Aug 12	Aug 14	Aug 18	Aug 15	Aug 16	Aug 17	Aug 19
3	Duration of Preliminary Warming-min	50	93	204	127	111	49	53	75	71
4	Duration of Test-min	62.3	35.5	30.5	58.9	38.0	26.5	60.3	75.8	40.8
5	Average Boiler Pressure-lbs	152.	156.9	156	150.2	150.1	153.2	152.5	151.5	152.9
6	Average Atmospheric Temperature-Degrees F	74	72	78	72	72	73.5	71	79	70
7	Direction & Force of Wind, Miles per Hour N ↑	 6 to 10	 0 to 2	 3 to 8	 5	 3 to 5	 5	 10 to 15	 3	 3
8	Observed Condensation for Test-lbs	432.6	97	106.1	176	109.5	96	189.5	246.5	128.5
9	Amount to be added to or subtracted from 8 to convert it to an equivalent amount which would have been observed had the average steam pressure been 150 lbs. & Atmos. Temp. 80° F	-10.4	-3.7	-1.8	-4.8	-3.0	-2.6	-6.4	-2.5	-5.0
10	Total Condensation under Standard conditions of Pressure and Temperature	422.2	93.3	104.3	171.2	106.5	93.4	183.1	244	123.5
11	Condensation per Minute	6.78	263*	3.42	2.91	2.80	3.52	3.04	3.22	3.03

* THE VALUE 263 IS PROBABLY TOO LOW, IT IS ESTIMATED THAT THE TRUE VALUE IS NOT LESS THAN 3.00

TABLE VI.

VIII.—*Standing Tests.*—All standing tests, save one, immediately preceded the corresponding running test. Standing Test C followed the running test.

The observed data, and the results which have been derived from them are presented as Table VI. Most of the lines in this table are self-explanatory, but there are a few which demand a word of explanation.

Item 8 gives the actual condensation for each test. But these values were not obtained under conditions which were precisely similar. The steam pressure was not the same for all tests, nor the atmospheric temperature, nor the wind. As a correction for variations in steam pressure and atmospheric temperature can safely be made on the assumption that the heat transmitted will be proportional to the difference of temperature between the steam inside the boiler and that of the atmosphere outside, a standard pressure and temperature have been assumed.

Item 9 gives the values which must be subtracted from the total observed condensation to convert it into an equivalent amount, which would have been obtained had the gauge pressure been 150 pounds and the atmospheric temperature 80 deg. F.

Item 10 gives the total condensation as corrected on the basis defined by Items 8 and 9.

Item 11 is obtained by dividing values given in Item 10 by the corresponding duration of test, giving a rate per minute which may be used for purposes of comparison. These values may be assumed to represent the conclusions to be derived from the standing tests.

No attempt has been made to correct results for different conditions of wind, but there can be no doubt that changes in exposure arising from this cause had a pronounced effect upon the results of the standing test. For this reason the results of the standing test are believed to be far less reliable for purposes of comparison than those derived from the running tests (a description of which is to follow), for in the running tests the effect of slight variations in wind velocity were swallowed up in the effect of the forward movement of the experimental boiler itself.

The results given for Test B (2.63 pounds per minute) are so low as to be fairly open to question. This was the first test made. There was then nothing with which to compare the results as they were obtained. Basing an estimate on the results of the running test, that for the standing test should probably not be less than three pounds per minute.

These considerations emphasize the undesirability of attaching importance to the comparative showing made by the different coverings during the standing test. The collective showing is, however, of great importance, but discussion of this matter will be reserved for a later paragraph.

IX.—*Running Tests. Observed and Calculated Data.*—A complete summary of the facts derived from the running tests is presented as Table VII. The following paragraphs concern such items in the table as require explanation:

"Duration of Test" (Item 2). The general process followed throughout each of the running tests has already been described. Every such test necessarily included some time during which the engine was at rest. The tests were

necessarily started before the train was put in motion. Accidental stops operated to increase the duration of the test, and the ten minutes at Maquoketa, during which a balance of the weighing tank was obtained, are included in the recorded duration of the running test. Finally, at the close, the train came to rest several minutes before it was practicable to end the test. The values, therefore, given as Duration of the Test represent the whole time between the initial and final balancing of the weighing tank; it is the period for which the record of condensed steam was obtained.

"Actual Running Time" (Item 3). Under this head appears the number of minutes the engine was actually in motion, and under the next head, "Actual Standing Time" (Item 4), is given the difference between the Duration of Test and the Actual Running Time. It will appear further on that the radiation losses as observed for a whole test can readily be separated into two parts, one applying to the standing time and the other to the running time. In this manner results are obtained which apply wholly to the conditions of running, the effect of all stops being eliminated.

"Direction and Force of Wind" (Item 7). The diagrams given in connection with this item show, in each case, the approximate direction of the wind with reference to the locomotive when the latter is assumed to be at rest. The figures given show that the velocity of the wind was always light, the highest not exceeding eighteen miles an hour, and this only for one test and for a brief interval. This fact, taken in connection with the arrows giving direction, make it clear that the actual air currents about the engine when at speed were always from front to rear, and not in the direction of the arrows shown. If the wind were ahead, this velocity in effect was added to the velocity of the engine; if from the rear, its velocity in effect was subtracted from the velocity of the engine. The fact that all wind velocities were low, compared with the velocity of the train, is depended upon to reduce to a minimum irregularities growing out of wind action, but it is evident that the conditions did not entirely accomplish such a result.

By comparing the diagrams of the table with the reference arrow at the left, the absolute direction of the wind may be estimated.

"Observed Condensation" (Item 9). The condensation collected for each quarter appears under this item together with the total of the complete test. The values given are those directly observed without any correction of any sort. As all condensation is the result of radiation, this item may be taken as a measure of the heat lost through the exterior surfaces of the boiler.

"Correction for Variations in Steam Pressure and Atmospheric Temperature" (Items 10 and 11). In all tests it was the endeavor to maintain a uniform pressure of 150 pounds upon the experimental boiler. Variations from this standard were not great, but the average of observations made at five-minute intervals is not the same for all tests. Again, the atmospheric temperature varied on different days. In order that results observed might be reduced to a common basis with reference to these two factors, the observed results have been reduced to equivalent results which would have been observed had the pressure been 150 pounds, and atmospheric pressure 80 degrees F., for all tests. This standard of

pressure and of atmospheric temperature is the same as was employed in connection with the standing tests (Paragraph VIII). It will be seen that the actual conditions agree nearly with the assumed standard conditions for all tests and that for three tests no correction at all is required.

"Corrections for Variations in Time of Running and in Speed" (Items 12 to 14). Attention has already been called to the fact that the running tests are actually made up of intervals during which the engine was in motion, and of other intervals during which it was at rest. This being so, and the time of running and the time of standing being known, it is easy to divide the observed condensation into two parts, one of which shall represent that which resulted during the period when the engine was standing, and the other that which resulted during the time the engine was in motion. Thus, the duration (Item 2) of Test B is given as 358.6 minutes, the actual running time (Item 3) as 313.3 minutes, and the standing time (Item 4) consequently as 45.3 minutes, and the total condensation (Item 11) is 1872.3 pounds. The rate of condensation while standing was shown to be 2.63 pounds per minute (see results from Standing Test, Table VI), so that during the 45.3 minutes the engine was standing, 119.1 pounds were condensed. The condensation while running, therefore, would be the total condensation, minus the condensation while standing, that is:

$$1872.3 \text{ pounds} - 119.1 \text{ pounds} = 1753.2 \text{ pounds.}$$

A determination in this general form has been made for all tests in order that the rate of condensation during the running time may be shown. Instead, however, of taking the actual running time and the actual standing time, there has been employed an assumed running time (Item 12) which is the same for all tests, and which is very near the actual time of all tests. The adoption of this assumed running time is justified from the following considerations: If, for a given test, the running time is slightly longer than for another test with which it is to be compared, it is evident that its rate of speed was lower and that the air currents, as a consequence would, other things being equal, be less severe in their effect upon the engine. There would, therefore, be injustice in determining the rate of condensation per minute in the two cases for purposes of comparison; by dividing the total condensation by the observed time. If, however, the total condensation observed during running is, in each case, divided by the same time, the result in each case carried with it its own correction for variations in speed of running. This is the process which has been followed in making up the statement of results. At the same time full and complete data is given which will permit comparison to be made on the direct basis if any are disposed to mistrust the assumptions already stated. The conclusion of this matter is represented by the "Condensation per Minute while Running" (Item 16). This factor represents, therefore, the observed condensation as corrected for variations in steam pressure, for variations in atmospheric temperature, and for variations in speed of running. It is probably as perfect a basis upon which to compare the merits of the various coverings tested as can be supplied by the information obtained during the tests. It is evident that since all condensation must have resulted from heat radiated, the smaller the amount of condensation the more efficient the covering.

"Efficiency" (Item 18) is the ratio of the heat saved by the application of the covering, to that which is lost when no covering is applied. Thus, if the bare boiler loses heat sufficient to condense ten pounds of steam per minute, the covering which reduces this condensation to five pounds saves half the original loss and has an efficiency of 50 per cent. Results obtained after this manner are given (Item 18). They represent the fraction of all the heat lost when the boiler is uncovered, which is saved by applying the several coverings tested. Thus, the covering, Test B, saves 8.59 pounds of steam per minute which is six-tenths that which it is possible to save.

X.—*Conditions Affecting Results for which no Corrections have been applied* are to be found in the varying thickness of covering experimented upon, and in the varying velocity and varying direction of the wind.

It may be concluded from results obtained that corrections for varying thicknesses, were it practicable to derive them, would be extremely small in value. Nevertheless, the effect of differences in the thickness of the several coverings is not in fact negligible, if results are to be directly compared.

The cooling effect of the wind will vary with its velocity and direction. When its direction is the same as that in which the train travels, its effect upon the locomotive is similar to that which would be produced if the locomotive were moving through still air at reduced speed. As each test involved a round trip over a given line of track, the direction of train motion was reversed in the middle of the test, thus reversing the effect of the wind, the average effect for the whole test remaining practically the same as though the whole movement of the locomotive had been in still air. This, of course, is strictly true only when the direction of the wind is in line with the track, but the argument has force in connection with all tests made. The tabulated statement of condensation by quarters (Item 9), compared with wind diagrams (Item 7), is instructive on this point. Thus, taking the second and third quarters, from Maquoketa to Anamosa, and from Anamosa to Maquoketa, respectively, Test B shows a constant direction of wind and a velocity of about two miles. From Maquoketa to Anamosa, *against* the wind, the condensation is 452.1 pounds; from Anamosa to Maquoketa, *with* the wind, the condensation is 410.7 pounds, a difference of 41.4 pounds. There can be but little doubt that the average of the two values will be very close to the result which would have been obtained had the engine been running in still air once over the line, at the speed which prevailed during the test.

Comparisons of this kind should be made with care. For example, from considerations just presented it would appear that the condensation for the last quarter should be less than for the first quarter, whereas the uncorrected data with which we are now concerned, shows it to be greater. The explanation is to be found in the fact that the return trip involved detentions, which made the time returning on the fourth quarter nearly half an hour longer than the outward time of the first quarter. The corrections for such irregularities have been applied to the results of the whole tests only, and not to the separate quarters.

Returning again to a consideration of wind effects it is to be noted that changing the direction of train motion does not compensate for the effect of side

winds. For this reason such winds, even when light, doubtless have a more serious effect in impairing the comparative value of the results than stronger winds which move along the line of the track.

Again, changes either in the direction or velocity of wind during the progress of a test constitute a source of serious disturbance. In the Test D₁, the wind moved with the engine during the first quarter, and, later in the test, changed so as to move obliquely with the engine during the return trip, with the result that the condensation for the whole test is probably somewhat less than it would have been had the direction remained unchanged. A similar change of wind, Test E, was against the engine, its effect being to give a greater amount of condensation than would have been obtained had the wind remained unchanged.

It having been requested at the meeting that a description of the coverings be included in the final Proceedings, the following is offered as additional information, and as much as can be given, consistently, at the present time.

The covering which is designated in the paper by the letter "B" is the cement covering in general use on the Chicago, & North-Western railway. The following ingredients are mixed into a plastic paste and applied in three coats, one being allowed to dry for about twelve hours before the next is applied. 1 part by volume No. X Sall-Mountain asbestos; 1 part lime, slaked, strained and allowed to set; and 1 part oak sawdust. After the second coat the boiler is wrapped with No. 20 wire. Four of the other coverings were of asbestos in various forms, and the fifth covering, not fifth in the tables, was of magnesia.

R. Q.

TABLE VII.

1	Designation of Test	FAIR WEATHER	B	C	D ₁	D ₂	E	F ₁	F ₂	G
2	a 1 st Quarter	106.2	86.5	88.7	86.0	88.7	86.1	120.2	85.6	84.5
	b 2 nd "	81.0	80.5	76.9	78.4	80.5	77.8	75.6	81.0	79.2
	c 3 rd "	75.6	77.4	73.1	77.8	75.7	80.0	76.6	74.5	
	d 4 th "	96.2	112.6	97.4	89.3	97.9	105.5	93.5	103.0	108.2
3	e Total for test	359.0	358.6	338.2	326.8	344.9	345.1	369.3	346.2	346.4
	a 1 st Quarter	95.0	81.5	82.9	81.5	83.1	81.6	98.5	81.0	81.1
	b 2 nd "	70.0	68.8	67.3	68.6	69.0	67.8	69.1	68.6	69.1
	c 3 rd "	73.5	70.3	72.7	71.2	73.3	72.5	68.7	73.5	71.2
4	d 4 th "	84.7	90.5	83.4	84.3	80.2	86.9	82.5	83.9	79.7
	e Total for test	323.2	313.3	306.3	305.6	305.6	308.8	313.8	308.0	301.1
	a 1 st Quarter	11.2	5.0	5.8	4.5	5.6	4.5	21.7	4.6	3.4
	b 2 nd "	11.0	12.2	9.4	9.8	11.5	10.0	6.5	12.4	10.1
5	c 3 rd "	2.1	5.8	4.7	1.9	4.7	1.8	11.3	3.1	3.3
	d 4 th "	11.5	2.3	12.0	5.0	17.7	18.6	11.0	18.1	28.5
	e Total for test	35.8	45.3	31.9	21.2	39.5	36.3	50.5	38.2	45.3
	a 1 st Quarter	14.6	148.2	153.3	150.8	149.9	150.6	149.9	150.6	152.1
6	b 2 nd "	14.1	150.9	146.3	150.2	148.5	151.3	150.8	152.3	151.8
	c 3 rd "	14.3	151.5	153.8	152.2	157.6	151.4	150.3	151.4	151.6
	d 4 th "	14.7	150.1	152.6	150.6	152.0	151.8	150.3	150.1	151.0
	e Total for test	145.8	150.1	152.6	151.0	150.5	151.3	150.7	151.0	151.6
7	a 1 st Quarter	79.8	74.3	81.3	72.8	76.8	81.3	81.5	79.0	78.2
	b 2 nd "	85.0	79.3	82.0	74.0	74.2	86.0	84.3	80.0	74.8
	c 3 rd "	82.0	85.8	82.0	76.3	79.3	90.7	90.0	81.0	84.6
	d 4 th "	82.0	83.3	81.3	77.0	78.0	90.3	88.2	81.0	83.3
8	e Total for test	81.7	80.3	81.6	75.0	78.2	86.8	85.5	80.3	81.1
	a 1 st Quarter	10.10.12	2	10.10.15	5	10.10.4	3.10.4	5.10.7	3.10.4	2.10.3
	b 2 nd Quarter	10.10.12	2	10.10.18	5	10.10.4	3.10.4	5.10.7	3.10.4	2.10.3
	c 3 rd "	10.10.12	2	10.10.18	5	10.10.4	3.10.4	5.10.7	3.10.4	2.10.3
9	d 4 th "	10.10.12	2	10.10.18	5	10.10.4	3.10.4	5.10.7	3.10.4	2.10.3
	e Total for test	10.10.12	2	10.10.18	5	10.10.4	3.10.4	5.10.7	3.10.4	2.10.3
	a 1 st Quarter	13.76.9	4.14.0	5.45.7	3.88.4	4.58.4	3.97.2	5.43.8	4.49.9	4.67.1
	b 2 nd "	1.37.8	4.52.1	4.13.6	3.75.2	3.97.7	4.6.7	4.11.9	3.90.7	4.18.4
10	c 3 rd "	9.75.4	4.10.7	3.43.2	3.93.7	4.01.9	3.63.7	3.78.2	3.93.7	4.02.2
	d 4 th "	11.68.1	5.90.5	4.79.1	4.27.4	4.44.3	5.15.1	4.37.6	5.60.3	5.75.5
	e Total for test	44.58.2	18.72.3	17.81.6	16.28.7	17.52.3	16.93.4	17.76.5	17.90.6	18.63.2
	Amount to be added to or subtracted from the total observed condensation to convert it into an equivalent amount which would have been observed had the engine steam pressure in the test been 150 lbs. and the steam temp 817° F.	+60.6	0.	0.	-31.0	-12.3	+37.3	+32.0	0.	+0.9
11	Total condensation for test under conditions -- 10	47.0.8	18.72.3	17.81.6	15.96.7	17.40.0	17.90.7	18.08.5	17.92.6	18.64.1
	Assumed time during which engine was running 10 min.	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
	Assumed rate of speed -- Miles per Hour.	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3
	Assumed time during which engine was standing -- duration of test minus assumed time engine was running = Item 2 (1) - Item 1 (2)	54.0	53.6	33.2	21.8	39.9	40.1	64.3	41.2	41.4
12	Total condensation during running = condensation for test minus the product of the rate of condensation while standing and the assumed standing time.	4357.7	791.5	1668.1	1535.3	1628.3	1589.5	1613.0	1617.9	1738.7
	Condensation per min. while running 28.3 miles per hour	14.27	5.68	5.47	5.23	5.34	5.21	5.29	5.30	5.70
	Reduction in condensation per min. while running at a speed of 28.3 miles per hour resulting from covering applied to 61% of total surface of boiler. Formula:	8.59	8.80	8.80	9.24	8.93	9.06	8.98	8.97	8.57
	Ratio of heat saved by covering to total heat transmitted from bare boiler	0.602	0.617	0.617	0.648	0.626	0.635	0.629	0.628	0.601

LIBRARY
OF THE
UNIVERSITY OF ILLINOIS.

DISCUSSION.

THE CHAIRMAN: Mr. Quayle, the author of the paper, is unable to be present at this meeting, and he has requested Mr. Whyte to make a brief discussion of the matter in presenting it to the Club.

THE SECRETARY: Mr. Quayle found it impossible to be here to-day, and Mr. Marshall is in the East, so Mr. Quayle requested me to make a few remarks on the paper by way of opening the discussion. The substance of the paper appears in that part of it preceding the appendix, and the discussion may well be confined to that part of it, referring to the appendix only for details of the apparatus used and methods followed.

In explanation of paragraph 2, it may be said that a Cochran steam separator was used to entrap the water from the steam passing from the boiler of the rear engine to the experimental boiler, and the separator was placed as close to the back head of the experimental boiler as possible. The water was drawn from the separator as frequently as was found necessary, so that the separator would not become filled and the water be carried into the boiler. There was a water-glass placed on the left side of the fire-box outside at the inner mud ring and the water kept at a fixed height in that water-glass. This was done by manipulating the valve which was at the rear of the cab, in the rear of the gangway, and the operator could observe the height of the water in the glass, and either increase the flow through the valve, or check it as was found necessary. The water that was drawn off in this way passed through a coil of pipe in the tank and was cooled in its passage to a barrel located in the coal space of the tank where it was weighed. The weighing, of course, could not take place while the locomotive was in motion, but the barrel was of sufficient capacity that weighing was not necessary between stations. No weighing was done between stations, but sometimes water was drawn from the barrel into a calibrated metal vessel.

In further explanation of Fig. 2, it may be said that the covering began, as usual, at the smoke-box ring and extended over, and covered completely, the cylindrical part of the boiler; the slope sheet, of course, was covered and the crown sheet down as far as an angle-iron, which is shown just above the words, "Top row of staybolts;" the covering extending back to the cab line. The dome was also covered, but, as explained in the paper, was not as well covered as the rest of the

boiler. The sides of the fire-box from the angle-iron down to the lower end was not covered, nor was the front end of the fire-box.

It should be noted that the values given in Table 1, make no distinction between the radiating values of the surfaces covered and uncovered; it appears that 61 per cent. of the surface was covered, but were it possible to distinguish the radiating values of the different parts of the boiler it would be found that in covering the part that was covered there resulted a saving greater than 61 per cent. of what would be possible were all radiating surfaces covered. The back head and the sides of the fire-box which were not covered were protected more or less from air currents by the cab, the machinery and the frame and its fastenings.

Referring to Fig. 1, the light-colored ring separating the boiler from the smoke-box shows the cement that was used to make a tight joint at that place. Ordinarily that joint is covered with a band of Russia iron, but in these tests the band was not replaced. The joint was carefully cemented, however, and the light mark shows the cement. Also the back end, where the cylindrical part of the boiler joins the fire-box, was similarly cemented. The jet of steam issuing from the stack, which seems to cut the bridge in two, was the outlet of steam to insure that there were no "dead ends" in the boiler; there was another leak at the whistle valve in the dome. On the rear engine is shown a pipe extending upwards from the dome and then to the right and down again; it was through that pipe that the experimental boiler was supplied with steam.

Table II gives some values in pounds of steam of condensation per minute, which values are the corrected values after corrections have been made for variations in steam pressure, atmospheric temperature and running speed; it is quite obvious why corrections were not made for variations in velocity and direction of wind, and it is believed that no one can make a fair correction for this. It can simply be stated, as it is, that sometimes the wind blew thus and so.

Table III shows the very slight difference between the different coverings. A committee reporting to the Master Mechanics' Association last year found that the cement covering was very inferior to other coverings, and looking for an explanation for such results, it appeared that the cement covering had not been given a sufficient time to dry. The efficiency of the covering depends very largely upon the amount of moisture in the covering, and the cement cover-

ing must be given time to become thoroughly dry. The results given in Table III show that cement coverings, when properly dried, are no less efficient than the other coverings. It cannot be selected from this table, because the covering which, apparently, shows the worst result is not the cement covering, that is, if there is a worst; the coverings show so close in efficiency that, as explained in the paper, when corrections are made for direction of wind or other variations, it is quite possible that this order would be reversed and the covering which shows the best here, might show the worst when other things are considered.

Further, the thickness of the covering has much to do with the efficiency, and a covering which shows 62 per cent. efficiency here, may be made to show 64 or 65 per cent., or more, by adding to its thickness. It appears that the thickness of these coverings was such that the difference in the quality of the coverings almost disappeared, so that if a covering which showed 62 per cent. efficiency could be increased in thickness to give a 65 per cent., or more, efficiency, and still not cost more than the covering which shows here the highest efficiency, it would have the same commercial efficiency as the thinner covering. There is a consideration, however, which must not be lost sight of; it may happen that size of boiler and other parts may bring the weight of a locomotive above the allowed weight, and in scheming to reduce the total weight the boiler covering may be required to part with its share, then the actual insulating value of the covering would require consideration. It is along this line that the manufacturers should experiment, to provide a light, efficient covering at lower cost.

You may notice the frequent occurrence of this sentence, "the results apply only to the boiler tested;" and in calculating the savings which may be produced each year by covering the boilers with different coverings, or by covering additional parts of the boiler, and basing the calculations upon any figures in this paper, you must consider everything which can affect the process of radiation. The additional parts to be covered are likely to be those which are not so much exposed as those parts now usually covered. Again, it is probable that the wind effects were much less than would be the average throughout the year, and this was one of the reasons for selecting mid-summer for the tests. It is believed that for other boilers and for other conditions, calculations may be based upon the re-

sults shown in the paper and made along lines therein explained, but it is well to bear in mind the old saying, "Do not theorize too far." It is best to be guided in a general way by the results of the experiments, rather than to attempt close calculations for results to be obtained under conditions differing widely from those under which the tests were made.

THE CHAIRMAN: The paper is now open for general discussion.

MR. F. G. GASCHÉ (Ill. Steel Co.): In the preparation of the paper, and in the experimental methods employed to secure the data which form its basis, the statement of the case seems to be so complete that nothing need be added in attempted elaboration of the work. It seems that the gentlemen engaged in this investigation might exhibit more "courage of their convictions" in the statement of paragraph 7, wherein they would emphasize as a fact "that the relative value of the several coverings as disclosed by the results here given, is not to be relied upon when the difference between them is small."

Having undertaken an investigation some years ago on several coverings, the speaker would assume to strengthen confidence in the results quoted in this paper, by quoting others which were derived at that time. There is an evident intention to avoid specific mention of the kinds of covering represented generally by the letters "B," "C," etc., which the speaker is bound to respect at this time by adhering to the general observation that his results corroborate the values more closely than the difference in conditions would permit one to anticipate. Further, the best covering in both experiments gives nearly the same saving when the results are reduced to a basis where comparison may be attempted.

The tests to which reference is made were presented in an article published by the speaker in *Power*, of the issue of December, 1896, in which the practice of referring to the several coverings by letters was followed. Without entering on a tedious quotation of all the points involved in the tests, the speaker announced as a general conclusion, that the condensation per square foot of surface of a conduit or pipe conveying a strong current of steam was much greater than with "dead end" pipe systems. The attempted explanation of this, attributed a certain heat insulating value to the moisture adhering to the surface of a conduit in which the only motion of steam was that due to radiation with the attendant condensation. When the pipe conveys a considerable quantity of steam, the moisture adhering to

the interior surface is continually removed by the steam current, favoring an intimate contact of the same with the cooler pipe surface and a more rapid escape of heat.

The tests were made on 115 feet of ordinary 8-inch pipe; five tests on the bare pipe, and from three to five tests on each of the several coverings. The several tests were necessary in order to get the relation between radiation and the difference of temperature between the steam and the air. They led to the following results where:

R =radiation in B. T. U. per square foot of pipe surface per minute.

t =difference of temperature of the steam and the atmosphere.

For the bare pipe:

$$R=0.139t$$

For the best covering:

$$R=0.0179t$$

For purposes of comparison, assume the total radiating surface be 358 square feet, the steam pressure 150 pounds per square inch and the air temperature 72 degrees F. The calculations lead to the following heat losses, arranged beside the results quoted in this paper:

CONDENSATION PER MINUTE, 358 SQUARE FEET.

	Pipe Surface	Locomotive Surface.
Bare pipe or boiler.....	17.15 lbs.	14.27 lbs.
Covering on pipe.....	2.20 "	.....
" 219 feet.....	.....	5.03 "
" 358 feet, assumed....	.....	3.08 "

While the difference of conditions attending the two forms of tests could be expected to show the divergence of results exhibited by the table, there is a sufficient agreement to give confidence to their indications. It can be asserted that we cannot apply the radiation losses peculiar to steam radiators, or "dead end" pipe systems, to cases such as presented by Mr. Quayle. The condensation losses for the bare boiler, according to paragraph 10, may be 10 per cent. of the total power developed by the machine, 62.3 per cent. of this being saved by the application of the "average" covering. It is seen that improvements in kind and application of covering rank in importance with improvements in the cylinders and valves of the locomotive, since it may be fairly assumed that the ordinary locomotive converts only 10 per cent. of the heat energy of the fuel into available work.

The important result exhibited in the diagram (Fig. 3) that the condensation increases with an increase in the velocity of the air

striking the locomotive, seems to warrant a re-investigation of the subject in a manner which will enable the experimenter to vary at pleasure the controlling factor of wind velocity. A difference of efficiency of covering of 2 per cent. on the basis of the assumption of Table V, will amount to \$12.00 per year per locomotive. An investigation of these efficiencies can be made with a precision approximating to scientific accuracy if the following method is employed:

Surround a locomotive, erected on dynamometer trucks, if desired, by a long flue or conduit through which air is delivered by a fan at varying velocities as required. Measure the condensation in the manner so carefully developed in the paper which has been presented, and check the results by the measurement of the heat carried away by the air currents. The condensations and efficiencies thus determined will apply unquestionably to the running conditions on a locomotive.

MR. G. W. RHODES: I would like to ask the Secretary how he accounts for the difference in Table II between the standing tests and the running tests. We are a little at a disadvantage because we do not know what coverings the letters designate. I would imagine that "G," is the North-Western cement covering (laughter), because I notice that in the standing test the "pounds of steam condensation per minute," Table II, is 3.03, but in the running test it is 5.70, that is, it is the best and the worst of the lot. If any of the supply men who sell boiler covering are present, I would like very much to have them tell me, on the quiet, whether their material is D₁. I find that D₁ stands pretty well; in standing test it shows 2.91, but in the running test it is decidedly the best, "pounds of steam of condensation" being 5.03. I have no doubt that a good many of us will busy ourselves to find out what coverings are represented by the letters, and if any of the supply men will enlighten us we will be much pleased. The explanation for assuming that "G" was the North-Western cement covering is this: Might there not be something in the conductivity of the material when exposed to different temperatures? For instance, the standing test was made, probably, in a pretty uniform temperature; the tests were made in the month of August, which is a midsummer month, and the selection of it was wisely made because the variations in temperature are not likely to be very great; nevertheless, the running tests are likely to be more variable than the standing test, and the question I would like to

know is whether the conductivity of the material shows any marked difference in the running tests. Supposing a boiler were lagged with stone or with thick metal would the running tests, on account of the conductivity of the material of the covering, show more poorly than those made with material which is a poor conductor of heat?

MR. F. A. DELANO (C., B. & Q. R. R.): I would like to ask some questions. I have read the paper, but have not completed reading the appendix and perhaps some of these questions are answered in the appendix. I notice in paragraphs 13, 14 and 15 is given a factor of correction for variations in the speed, in the atmospheric temperature, and in the steam pressure. May I ask whether these factors were checked by actual experiments? One reason for asking that question is, it seems to me, that the factors might vary with different coverings, especially so far as the changes of speed are concerned. The point that Mr. Rhodes makes is that the porosity or conductivity of the material used for lagging might make a worse comparative showing at high speeds than a more dense material. Then I am at a loss to understand one statement that is made at the end of a paragraph, to-wit: "Tests at speed are more reliable than standing tests." That is not usually the case; it is usually more easy to get the conditions exactly right when everything is quiet than when moving.

THE CHAIRMAN: The answer to the question that has been raised with reference to the statement that the tests at speed are considered more reliable than the standing tests, should include a statement of the following facts: The standing tests were made out of doors, sometimes in still air and sometimes in the presence of some little wind. The whole course of the experiments showed the effect of air currents about the boiler to be marked, and the fact that the wind was variable during the standing tests, leaves them somewhat open to question. The running tests were less affected by variation in wind velocity because, as is explained in the paper, the velocity of the locomotive itself was sufficiently high to reduce to a negligible amount the effect of slight changes in wind velocity.

MR. H. C. TODD (Chicago Fire Proof Covering Company): The railway world at large cannot feel grateful enough to the C. & N.-W. railway for the series of experiments made at Clinton, Iowa. No reliable data were at hand previous to that time. The report is admirable in many features. It does not seem just, however, to

slight the influence of thickness of coverings. If one covering is 20 per cent. thinner than another, there must be a marked difference; 2 per cent., 3 per cent., 4 per cent., thinner or thicker does not amount to much, we admit, but suppose a covering to save 90 per cent., when it is $1\frac{1}{2}$ inches thick, the addition of another $1\frac{1}{2}$ inches would again save 90 per cent. of the remaining 10 per cent. lost; or $1\frac{1}{2}$ inches + $1\frac{1}{2}$ inches = 3 inches, would save 99 per cent. Thus, if a covering $1\frac{1}{4}$ inches thick saved 90 per cent. on the surface covered, it would save for every $\frac{1}{4}$ -inch additional 37 per cent. of the loss up to that point. A good covering saves in about the following proportion:

$\frac{1}{4}$ -inch saves	39 per cent.	loses 61 per cent.
$\frac{1}{2}$ " "	62.8 "	" 37.2 "
$\frac{3}{4}$ " "	77.3 "	" 22.7 "
1 " "	86.2 "	" 13.8 "
$1\frac{1}{4}$ " "	91.6 "	" 8.4 "
$1\frac{1}{2}$ " "	94.9 "	" 5.1 "
$1\frac{3}{4}$ " "	96.9 "	" 3.1 "
2 " "	98.1 "	" 1.9 "

In the same manner act all coverings. Hence, it is perfectly feasible to show the exact saving with equal thickness. For the running test, the figures of losses in pounds of water per minute, with locomotive No. 626 were:

Observed loss for actual thickness in pounds of water per minute

A	B	C	D	D ₂	E	F	F ₂	G
14.27	5.68	5.47	5.03	5.34	5.21	5.29	5.30	5.70 lbs.

Actual thickness of covering

A	B	C	D	D ₂	E	F	F ₂	G
0	1.34	1.49	1.45	1.57	1.28	1.56	1.56	1.49 in.

Loss for equal thickness of covering, $1\frac{1}{2}$ in., pounds of water per minute

A	B	C	D	D ₂	E	F	F ₂	G
14.27	5.50	5.45	5.00	5.63	4.97	5.57	5.58	5.66 lbs.

Hence the differences with coverings of equal thickness are greater than they were with actual observed coverings. The differences are in per cent. of greater loss.

Actual thickness (Unit D)

A	B	C	D	D ₂	E	F	F ₂	G
+184%	+13%	+8.2%	0	+6%	+3.4%	+5.1%	+5.2%	+13.3%

Corrected equal thickness (Unit E)

A	B	C	D	D ₂	E	F	F ₂	G
+189%	+10.8	+12%	+1%	+14%	0	+12.5%	+12.6%	+15.6%

Hence we would consider those differences much more vital than the report seems to indicate. Runs D_1 and D_2 were made with the same material, once wet and then dry. D_1 is in many ways abnormal; it was the shortest time on the road, had the lightest, most favorable wind. The manufacturers themselves did not consider the run fair and demanded a repetition. D_2 is nearly normal and is also consistent with the results observed on D_1 material in a quiet laboratory test, while D_1 is not. Even without corrections, omitting the plainly unfair D_1 , differences from 3.6 per cent. to 13 per cent. occur; this means on \$600 a year per engine, as Mr. Quayle correctly figures the losses of a bare boiler, sums of \$21.60 to \$80, or twice the first cost of almost any covering.

The standing test is of no value whatever. As the table shows in all of them, winds of from 0 to 18 miles an hour prevailed; and Mr. Quayle himself says that wind is equal to so much train speed, it means that running tests in windless atmosphere with an engine running 0 to 18 miles an hour, were called "standing tests." How can the wind be called "negligible" with a train speed of only twenty-eight miles; if the wind of sixteen miles, as observed, is against the engine, it is equal to a net train speed of $28+16$ or 44 miles in a windless atmosphere; or, if with the train, $28-16=12$ miles, or a difference of 283 per cent., or a net difference even in a covered boiler of from .5 to 3.8 pounds per minute condensation. Especially did runs A, C, E, F_1 suffer from wind, while D_1 , D_2 , F_2 , G were favored, especially D_1 which had favorable (rear wind) on three-quarters while E had twice as heavy head wind on three-quarters. E was, besides, 20 per cent. thinner than any other covering. E suffered by far the most from the wind. The bare boiler "standing test" was in a wind of ten miles per hour. This is not standing. Our expert figured that for every mile head wind, or train speed, a loss per minute on bare boiler of No. 626 was 0.28 pounds of water condensed from 150 pounds pressure to 80 degrees Fahr. This is only wrong between the limits of 0.27 to 0.29 pounds; on a covered boiler, according to the saving in per cent., this becomes about 0.11 pounds per minute. This figure allows reducing all runs to windless runs, but the manner of obtaining it and details would lead too far for this discussion. Later on, when the same experiments will be repeated with anemometer and ventometers, exact data will be gathered; but it will be found that the figure 0.28 pounds

which is equal to about 0.001 pounds per square foot per minute per mile or 3.6 pounds per square foot per hour for sixty-mile speed, is not very far wrong. Corrected with these wind data, the different runs give approximately the following net results in a windless run:

Loss per minute in a windless run, pounds of water

A	B	C	D ₁	D ₂	E	F ₁	F ₂	G
13.6	5.50	5.17	5.12	5.15	4.60	5.12	5.10	5.59

Difference, expressed in greater loss in per cent. (Unit E)

A	B	C	D ₁	D ₂	E	F ₁	F ₂	G
+180%	+18%	+13%	+11%	+12%	0	+11%	+10%	+21%

The effect of the slanting wind is considered in these corrected formulæ. Including all corrections, wind, thickness, temperature, pressure, etc., the final results for runs in windless atmosphere, coverings of equal thickness are probably correct within 4 per cent.:

Fully corrected loss per minute, equal thickness, windless run, pounds water

A	B	C	D ₁	D ₂	E	F ₁	F ₂	G
13.6	5.32	5.15	5.09	5.39	4.36	5.43	5.39	5.55

Greater loss (Unit E)

A	B	C	D ₁	D ₂	E	F ₁	F ₂	G
+235%	+22%	+18%	+13%	+24%	0	+25%	+24%	+27%

Total saving per year, per cent.

A	B	C	D ₁	D ₂	E	F ₁	F ₂	G
0	60.9%	62.1%	62.6%	60.4%	68%	60%	60.4%	59.2%

Value of saving in one year

A	B	C	D ₁	D ₂	E	F ₁	F ₂	G
0	\$365.40	\$372.60	\$375.60	\$362.40	\$408	\$360	\$362.40	\$355.20

Compared with G (lowest for same thickness) the others save in a year more.

B, \$10.20; C, \$17.40; D₁, \$20.40; D₂, \$7.20; E, \$52.80; F₁, \$4.80; F₂, \$7.20; G, 0.

Any covering, other things being equal, will save the more the fewer joints. These joints in number were:

Number of joints, opening extending from boiler to jacket

B	C	D	E	F	G
0	204	80	...	204	204

Number of joints overlapped

B	C	D	E	F	G
0	24	...	...

The cost of applying is quite an item to the railway; the report

makes no special mention of this, but there must be considerable differences, about in proportion to the number of joints as shown in the above table.

MR. J. F. DEEMS (C., B. & Q. R. R.): I would like to ask a question, which I think is not out of the way: Was there any test made with wood lagging?

THE SECRETARY: There was no test made with wood lagging. Replying now to the question raised by Mr. Rhodes, in regard to the effect the porosity of the lagging has upon its efficiency, during standing and running tests, I believe that it is not the present understanding that a porous lagging is necessarily less efficient in a moving atmosphere, if the pores are sealed so that there will not be a circulation of air through the pores. The reason wood lagging was not tested, was because the C. & N-W. Ry. is not using wood lagging, and a fair average test could not be made without applying the lagging several months before making the test. Wood lagging when first applied, and if the workmanship is good, is a good heat insulator; but it is quite impossible to obtain thoroughly dry lumber for this purpose and the result is that after it has been subjected to the temperature of the boiler for a longer or shorter time the wood shrinks and the joints open, and the wood is charred and rattles from place and soon becomes of little use as an insulator.

MR. DEEMS: I think that there is no one present who would attempt to defend wood lagging as it has been put on in the past, put on practically green and allowed to shrink away, but a thought occurred to me in this connection. In paragraph 7, the following statement is made: "But service conditions which were necessary to the general demonstration could not always give similar conditions for different tests, though it is believed that no single test was affected by variations of conditions, by more than 2 per cent. or 3 per cent., an amount which would seem to be entirely negligible." My idea was this; there is so little difference in the different laggings, that, as stated here, "such a variation in results would be negligible if the efficiency of a single covering only were involved," at least it says a very slight difference in manner of applying, or other slight defect, would change these results. If there is so little difference in the different laggings it may be possible to so treat wood lagging that it will not char and shrink away, and I think every one will admit that it is the nicest lagging to handle and can be put on

for about one-quarter or one-third of what the other laggings cost, and inasmuch as there seems to be such a slight difference in them, we do not know but that the wood might be treated in some way to prevent shrinking and charring and used to advantage. I know that a good wood lagging placed on a pipe is, when new, almost equal to the best covering obtainable. I realize, however, that wood lagging will shrink when it is put on green and allowed to dry.

MR. H. E. SMITH (C., M. & St. P. R. R.): On the St. Paul road, we attempted to do that very thing, that is to say, we put on what is known as fire-proof paint, with the idea of preventing the charring of the wood. But the charring of wood is largely a question of temperature. If the wood is subjected to a certain temperature it is going to char, whatever there is over it, even if it is sealed up entirely from the air. That condition, it seems to me, mitigates against any benefit being derived from the treatment of the wood. You can readily prevent wood from taking fire, but not from charring, and that is, I think, the action of practically all fire-proofing compounds.

MR. WM. MCINTOSH (C. & N-W. Ry.): While wood lagging affords fair protection when new and carefully fitted, it soon becomes shrunk and charred to such an extent that it is of no practical value as a boiler covering. We find that it costs about half as much as the plastic material used by the C. & N-W. Ry. The records of tests made at West Burlington in 1898 by the Master Mechanics' committee show up very favorably for wood, but this record has no practical value as the sample tested was dry pine in two semi-circular pieces nicely fitted to the pipe and sealed at the ends, and where the two sections were joined together—conditions which could not be duplicated in practice.

MR. R. H. SOULE (Baldwin Locomotive Works.): These tests evidently were planned and executed with the utmost care and are of great value, and I doubt whether sentiment among railroad men and locomotive builders and manufacturers of boiler coverings will create a demand for any more tests of this character for some time to come; therefore, whatever lessons are to be learned from tests of boiler coverings, we ought to learn right now. The most surprising result that has been brought out is the apparent uniformity of the efficiency of the different coverings tested. This being the case, it is suggested at once that there must be some one element common to them all,

which is the effective agent as a non-conducting and non-radiating covering. We all know that air, when confined and not allowed to circulate, is a very efficient non-conductor and non-radiator; and that raises the question in my mind whether, after all, it is not the air which is common to all these forms of lagging which is really preventing radiation. They are all porous and plastic, and they all more or less imprison air in their interstices. If it is the air which is the effective agent in preventing radiation, we might, perhaps, conclude that no one of these coverings was absolutely necessary, but that a properly constructed air covering would be good enough; but that is manifestly impracticable, because we can hardly conceive of so constructing a locomotive jacket that it would not allow the confined air to circulate. You would find air leaks that would let the hot air out at the top, and let the cold air in at the bottom, and the whole object of the arrangement would be defeated. But if there is any merit at all in the idea that the confined air, the stagnant air, which is not allowed to circulate, does the business, then we are naturally led to consider whether we can accomplish the same object by confining that air by some cheaper material, and, if so, whether our friends who are manufacturing boiler coverings may not produce for us some cheaper material than any they have given us yet, and give us just as great efficiency in protecting the boiler.

Allusion has been made to tests of boiler coverings on steam pipes; it occurs to me that the conditions would be quite different in steam pipes from what they are in locomotive boilers; in a steam pipe the steam is in motion against the inside of the pipe and the outside air presumably is stagnant, but in the locomotive boiler you have reversed conditions, the steam confined in the vessel being stagnant, and the outside air being in rapid circulation; so it is not surprising that the results reached from these service tests of coverings on locomotive boilers conflict with the results reached by the tests of coverings on steam pipes.

In regard to the cost of the coverings, the first application of magnesia sectional covering that came under my notice cost \$110.00, but it was not very long, perhaps less than two years, before the cost was brought down to one-half of that, or about \$55.00, and it seems to me there is considerable hope of our being able to go on and produce other locomotive coverings which will perhaps split the price in

half again, and that is the practical question that appeals to us railroad men I think.

I have just been informed that the Baldwin Locomotive Works, within the last year, built a number of locomotives to English specifications and drawings, where air jackets were applied. Angle irons were first attached to the body of the boiler, and a regular planished iron jacket was then fitted over them. After the jacket sheets had thus been fitted, they were removed, and had $\frac{3}{8}$ -inch felt sheeting glued to them on the inside. When the engines were erected for service, the jacket sheets with the $\frac{3}{8}$ in. felt sheeting linings thus attached to them were again drawn tightly over the angle irons, and were riveted up, especial care being taken to close with pieces of felt sheeting all possible leaks in the jacket, so as to make it practically air tight.

MR. W. W. JOHNSON (Keasbey & Mattison Co.): We are all, I am sure, greatly indebted to the Chicago & North-Western road for their generosity in furnishing equipment and men for the test that was conducted under their auspices at Clinton last summer. Nothing better illustrates the need of completely insulating every inch of heat radiating surface of a locomotive boiler than the results shown by this test, which, notwithstanding the fact that some of "the results obtained" . . . "can hardly fail to occasion surprise," and are "fairly open to question," promises to mark an epoch in the history of locomotive laggings. If an average efficiency of 62.3 per cent. saving can be obtained in the month of August, with the locomotive running at the rate of less than thirty miles an hour, we can readily surmise, without overworking our imagination, something of the degree of efficiency which might be obtained when running at a speed of fifty or sixty miles an hour in, or below, a zero temperature.

The main fact established by this test is the need of preventing, as far as possible, the *radiation* of heat which is constantly going on during the time that the locomotive is under steam pressure, for heat and work are convertible, the one into the other. For every degree of heat lost, a proportional equivalent of mechanical force disappears.

The next question naturally in order is, what is the most effective and economical method of preventing these heat units from leaving the service of the boiler until they have faithfully performed their duty and received an honorable discharge? There is a practice, founded upon an erroneous theory, of putting hoops around a locomotive boiler, and placing the lagging upon the hoops. The theory is that the

space thus created between boiler and lagging contains "dead air," which is, of course, the best possible non-heat-conductor. The idea is, at first presentation, alluring and full of promise, a promise, however, that, like a "wild-cat note" on a broken bank, is never redeemed. Air is elastic, and is expanded by heat, thus becoming specifically lighter, and under conditions just described it loses no time in forcibly diffusing itself into the outside air of greater density. Air is not "dead," even when hermetically sealed, unless it is also *non-circulating*. As surely as the blood carries life when circulating through our veins, so does hot air radiate heat when circulating through a confined space. Prof. John M. Ordway demonstrated years ago, that while we must depend upon air to prevent the escape of heat by radiation, that air must not be allowed to circulate, and in order to realize the best possible results, it should be held immovable in microscopic spaces. When so entrapped there can be no transmission of heat except by the comparatively sluggish process of *conduction* from air-cell to air-cell.

There are some types of locomotive laggings which, although cheap at *first cost*, rapidly deteriorate when in use, until in a comparatively brief time they possess very little merit as savers of heat units. The *value* of a lagging from an economical standpoint may really be in almost inverse ratio to its *apparent* value from a mere radiation test, because the equally important factors of structural strength and durability may be lacking. For instance, mineral wool is one of the very best heat retardents when in a light and fluffy condition, but it is so easily consolidated by vibration that in a very short time it becomes comparatively worthless. And asbestos fibre, when light and fluffy, makes a most excellent non-heat-conductor, but experience soon taught us that one very vital quality, namely, elasticity, usually possessed by organic fibre, was lacking in the inorganic fibre of asbestos and the vibrations and concussions to which locomotive boilers are subjected, soon break down the air-entrapping structure of fibrous asbestos, leaving a matted mass of mineral matter, sadly lacking the heat-entrapping air-cell.

Edward Atkinson, President of the Boston Manufacturers' Mutual Fire Ins. Co., in discussing "Steam Pipe Coverings, Boiler and Cylinder Laggings," says: "Asbestos being an incombustible and fibrous substance may be, and is, used as a bond for holding magnesia and other non-heat-conducting substances in position. It is

also used in the manufacture of air-cell covering for the purpose of holding a very large amount of entrapped air. In this way it serves a purpose for which it would be wholly unsuitable by itself, as it is liable to become more and more solid under vibration, even if first used in a porous or fluffy condition without combination with other substances." Magnesium carbonate, popularly known as "magnesia," holds entrapped air to the extent of from 85 to 90 per cent. of its bulk. It is by virtue of this large proportion of air-cells that it possesses its well known non-conducting qualities. The life of magnesia lagging is almost limitless under all ordinary conditions of railroad practice. The sectional blocks of magnesia upon being saturated with water undergo no change of size or shape, and they neither shrink nor warp from heat. Their structural strength, in view of their levity, is so remarkable as to justify the friends of "magnesia lagging" in swearing *by* it, and its competitors in swearing *at* it. The blocks will withstand a pressure of ninety pounds to the square inch before crushing, and can be removed and re-applied any number of times without breaking.

One point in the report of this test is so contrary to all my experiences and preconceived ideas regarding the advantage of thickness of material and the effect of moisture in boiler lagging that I venture to refer to it here. After testing D_1 , it was found to be so saturated with moisture upon removal of the jacket that its representative requested, and was granted, another trial. A new set of lagging was sent for, received, and tested. It is designated in report of test as D_2 . It was of exactly the same material, but dry, and 12-100 of an inch thicker than D_1 . The temperature in each case was the same, difference in force of wind was negligible, and yet D_1 is credited with a non-heat-conducting efficiency of 2.2 per cent. greater than D_2 , its running mate, of exactly the same material, which, according to Table V, is equivalent to a money saving value of \$12.00 per annum.

MR. G. W. CUSHING (Franklin Mfg. Co.): The paper on boiler laggings presented by Mr. Quayle has many points of interest for officials in charge of locomotives to consider, and it is fortunate for all users and makers of laggings that the test of them by the C. & N-W. Ry. was conducted mechanically and technically by men of recognized ability and experience, and under such favorable conditions. It has heretofore been somewhat of an open question, so far as *proven data*

is concerned, what to use and how to use it, and it has troubled officials at times to decide upon their duty, considering the cost, in relation to efficiency of laggings.

One noticeable result of the test is the close agreement developed in efficiency of the several laggings used, and, one of them being a plastic cement covering, the field appears to be well represented therein, and the average value of good locomotive covering is established for the first time, so far as it can be shown under conditions of this test.

That speed should be considered in deciding upon a thickness for laggings is evident, as also that there are losses additional due to higher steam pressure, larger boiler shells, and to zero weather. The test was with $1\frac{1}{2}$ -in. thickness of lagging, practically, on a boiler of medium size, with only 150 pounds of steam, and with atmosphere at 80 degrees. Now, referring to the items covered by report (paragraph 14), it is shown that a change in atmosphere to zero would increase the losses due to radiation $3\frac{1}{2}$ per cent. for each 10 degrees of reduction, or a total of 28 degrees. Item 15 shows that an increase of steam pressure on boiler to 200 pounds would also increase the heat losses 8 per cent., a total of 36 per cent. loss to be counted upon and be provided for, as must be inferred by an increase of thickness in laggings.

Add to these the loss due to high speeds and large boilers, and it would appear necessary for users of laggings to consider and specify a proper thickness of those they consider suitable to meet the case. I have taken this view for sometime past in discussing the subject with officials, and the report gives abundant warrant for so doing. It is practicable to greatly impair the value of a good lagging by specifying a less thickness than the case properly calls for.

The paper takes notice of heat losses from the shell of boiler only, but it is clear that all exposed steam and water pipes and other surfaces radiating heat should be protected from heat losses and the atmosphere.

MR. W. H. MARSHALL (C. & N-W. Ry.): When I first read Prof. Goss's report of the lagging tests which form the subject of Mr. Quayle's paper, it seemed desirable to separate, if possible, the losses taking place through the bare portions of the boiler from those arising from the heat radiated through the lagged surfaces. There are several reasons which make this information most accepta-

ble. In the first place, the relative efficiency of the various coverings would be more clearly shown, when from the total condensation is deducted the fixed losses occasioned by bare surfaces. In the next place, such a separation of losses would show whether it is necessary to cover surfaces ordinarily left bare, such as the throat sheet and fire-box sides below the running board, and the back head of the boiler. Furthermore, as the covering of these additional surfaces in an acceptable manner is not easy, the saving to be derived, if known, would be a guide in determining the cost or inconvenience which one would be warranted in meeting, to give the boiler the additional protection from radiation.

To determine the losses from the uncovered surfaces, directly, from the results of the tests is impossible. To calculate them approximately requires several assumptions, and for my own personal information I made these assumptions, and calculated a table of losses which brings out several facts so clearly and is, in my estimation, so fair to all the coverings tested, that I have thought it proper to present it in abbreviated form in this discussion. It is given herewith.

The method used in calculating the loss through the uncovered surfaces was as follows: One of the best known coverings used in the tests, which has been frequently tested in laboratory work and whose efficiency is well known under those conditions, was assumed to have an efficiency of 80 per cent. when the locomotive was running at 28.3 miles per hour. I believe this figure is very close to the actual truth, though if tests could be made to confirm it, the percentage of efficiency might be found to be a little higher. On this basis it was found that the loss through uncovered surfaces while running was represented by the condensation of 3.07 pounds of water per minute. This is more than one-half of the total condensation per minute for the least efficient lagging, and when deducted from the total condensation, shows a greater difference between the performance of the various laggings than indicated on the face of the actual returns from the tests.

The separation of the losses in this manner has been applied to both the standing and running losses, and the yearly loss calculated on the basis of the engine running 250 hours per month at 28.3 miles per hour and standing 200 hours per month under steam, the average temperature of the atmosphere being taken at 50 degrees, and the cost of coal at \$1.50 per ton. The table shows the highest

Deducted from Report of Lagging Tests: showing Probable Losses through Surfaces Lagged and through Surfaces Unlagged, and the Annual Cost of these Separate Losses.
(W. H. Marshall.)

No. of Line	DESIGNATION OF LAGGING.	A. (Bare Boiler).	B.	C.	D.	E.	F.	G.
1	Total condensation during test (line 9, Table No. 3 of report).	4658.2 lbs.	1572.3 lbs.	1781.6 lbs.	1691.0 lbs.	1693.4 lbs.	1763.6 lbs.	1863.2 lbs.
2	Total condensation corrected to 150 lbs. steam and 50 deg. atmospheric temperature (line 10, Table 3 of report).	1718.8 lbs.	1672.3 lbs.	1781.6 lbs.	1669.3 lbs.	1730.7 lbs.	1779.6 lbs.	1864.1 lbs.
3	Actual standing time (line 4, Table 3 of report).	35.8 min.	45.3 min.	31.9 min.	30.2 min.	36.2 min.	44.3 min.	45.3 min.
4	Assumed rate of condensation while standing. Total condensation while standing, based on rate assumed in line 4.	6.76 lbs.	3.00 lbs.	2.95 lbs.	2.85 lbs.	2.85 lbs.	2.85 lbs.	3.00 lbs.
5	Total condensation while running (figures in line 2 minus those in line 5).	242.7 lbs.	135.9 lbs.	94.1 lbs.	86.1 lbs.	103.5 lbs.	126.3 lbs.	135.9 lbs.
6	Actual running time (line 3 of report).	1476.1 lbs.	1736.4 lbs.	1687.5 lbs.	1583.2 lbs.	1627.2 lbs.	1653.3 lbs.	1728.2 lbs.
7	Condensation per minute while running (line 6 divided by line 7).	333.2 min.	313.3 min.	306.3 min.	305.6 min.	308.8 min.	313.4 min.	301.1 min.
8	Average speed in miles per hour.	13.82 lbs.	5.54 lbs.	5.51 lbs.	5.18 lbs.	5.27 lbs.	5.27 lbs.	5.74 lbs.
9	Total condensation per minute while running, corrected to average speed of 28.3 miles per hour.	26.7	27.6	28.2	28.3	28.0	27.6	28.7
10	Condensation per minute from unlagged surfaces while running 28.3 miles per hour (calculated).	14.25 lbs.	5.62 lbs.	5.52 lbs.	5.18 lbs.	5.30 lbs.	5.34 lbs.	5.70 lbs.
11	Condensation per minute from lagged surfaces while running 28.3 miles per hour (line 11).	3.07 lbs.	3.07 lbs.	3.07 lbs.	3.07 lbs.	3.07 lbs.	3.07 lbs.	3.07 lbs.
12	Condensation per minute from lagged surfaces while running 28.3 miles per hour (line 10 minus line 11).	11.18 lbs.	2.55 lbs.	2.45 lbs.	2.11 lbs.	2.23 lbs.	2.27 lbs.	2.63 lbs.
13	Condensation per minute from lagged surfaces while running in atmosphere at 50 deg. temperature.	12.30 lbs.	2.81 lbs.	2.70 lbs.	2.32 lbs.	2.45 lbs.	2.50 lbs.	2.89 lbs.
14	Loss through lagged surfaces annually while running, assuming average service of 250 hours per month at 28.3 miles per hour, average temperature of air 50 deg., and 1 lb. of coal equal to 8.2 lbs. of water evaporated from 367 deg. temperature to steam at 307 deg. (150 lbs. pressure). Coal.	135.0 tons.	30.8 tons.	29.6 tons.	25.5 tons.	26.9 tons.	27.4 tons.	31.8 tons.
15	Loss through unlagged surfaces under same conditions as line 14. Coal.	37.0 tons.	37.0 tons.	37.0 tons.	37.0 tons.	37.0 tons.	37.0 tons.	37.0 tons.
16	Assuming ratio of losses from lagged and unlagged surfaces to be same when standing as when running, then condensation from unlagged surfaces per minute equals when standing in air at 50 deg.	1.795 lbs.	1.795 lbs.	1.795 lbs.	1.795 lbs.	1.795 lbs.	1.795 lbs.	1.795 lbs.
17	And condensation from lagged surfaces under conditions of line 16 equals per minute.	5.64 lbs.	1.48 lbs.	1.43 lbs.	1.32 lbs.	1.32 lbs.	1.32 lbs.	1.48 lbs.
18	Loss of coal per year from lagged surfaces, engine standing 200 hours per month in air of average temperature of 50 deg.	49. tons.	12.8 tons.	12.4 tons.	11.5 tons.	11.5 tons.	11.5 tons.	12.8 tons.
19	Loss of coal through unlagged surfaces under same conditions as line 18.	15.8 tons.	15.8 tons.	15.8 tons.	15.8 tons.	15.8 tons.	15.8 tons.	15.8 tons.
20	Total loss of coal through lagged surfaces per year, including time running and standing (line 14 plus line 18).	184 tons.	43.6 tons.	42.0 tons.	37.0 tons.	38.4 tons.	38.9 tons.	44.6 tons.
21	Total loss of coal through unlagged surfaces per year, including time running and standing (line 15 plus line 19).	52.5 tons.	52.5 tons.	52.5 tons.	52.5 tons.	52.5 tons.	52.5 tons.	52.5 tons.
22	Total loss in money through lagged surfaces per year, assuming coal at \$1.50 per ton.	\$276.00	\$65.40	\$63.00	\$55.50	\$57.60	\$58.35	\$66.90
23	Total loss in money through unlagged surfaces per year, coal at \$1.50 per ton.	\$78.75	\$78.75	\$78.75	\$78.75	\$78.75	\$78.75	\$78.75

NOTE. This table was prepared on the following basis: First, The total condensation is derived from the tests. Second, The running and standing time is the same as in the tests. Third, The standing condensation per minute is taken at figures believed to be more consistent than those derived from the tests. Fourth, Running condensation is total condensation minus *assumed* standing condensation. Fifth, Condensation per minute running is obtained for actual speed of tests and then corrected to a speed of 28.3 miles per hour. Sixth, Condensation due to uncovered surfaces is calculated by assuming an efficiency (when running) of 50 per cent. for one well known covering used in the tests. Seventh, The average temperature of the atmosphere for the year is taken at 50 deg. Lagged surface as applied to bare boiler means that surface lagged in other tests. Unlagged surface as applied to bare boiler test means the surface not covered in other tests.

loss through any one lagging per year to be \$66.90, and the smallest loss to be \$55.50, while the loss through those surfaces not covered amounts to \$78.75. In other words, by selecting the best covering, one may save \$11.40 per year in coal (providing the covering is durable) with a boiler of the size experimented upon, while by putting the lagging upon the surfaces not now covered, one may make an additional saving of say \$50.00 out of the \$78.75 now lost through the bare sheets. This shows the economy resulting from a good covering, and it also emphasizes the even greater importance of covering as much surface as possible, the attainable saving in the latter course being about five times as much as the former.

It is not an easy proposition to provide a suitable method of covering the fire-box of a boiler below the running board. On the Chicago & North-Western Ry. we drill all stay-bolts telltale and we inspect all stay-bolts every thirty days. We believe all bolts should be accessible from the outside. It is evident that the covering applied to these flat surfaces should press tightly against the sheet, should leave the ends of the stay bolts visible, and should not interfere with the renewal of stay-bolts. Our general foreman at Chicago shops has suggested what appears to be the most feasible method of accomplishing these results, and we are about to cover several fire-boxes in the manner suggested by him.

In looking over the results of the standing tests you will notice the figures show wide fluctuations and for reasons clearly set forth in the paper. As the standing condensation is deducted from the total to give the loss while running, it follows that the worse the covering appears in the standing tests, the better it will show while running. I have endeavored to correct this inconsistency by assuming more nearly uniform values for the standing losses. The report assumes that if a test were conducted at a slightly lower speed than 28.3 miles per hour, the longer running time would offset the slower speed. I believe that this is entirely correct within the small limits of variations occurring in these tests, but as I have heard this matter questioned by some, I have calculated each test at its own speed, and then corrected the results for speed, bringing each to a basis of 28.3 miles per hour. The results were almost identical with the figures given in the paper, being not more than .02 of a pound different except in one case, and then the difference was trivial. As my calculations were made in this way, I have allowed them to

remain in this form in the table presented. The difference between the figures given in line (10) and those given in the paper are due only to the different rate, of condensation while standing, assumed by me (see line 4).

To complete the comparison between the different laggings, the results ought to be corrected for differences in thickness, but I have not been able to do this. It is my opinion, however, that the range of economy covered by the various laggings tested, as given in the table accompanying this discussion, is practically correct, and while there is sufficient difference between the coverings to make a correct choice productive of economical results, by far the greatest lesson of the tests is the necessity of covering as much of the boiler as is feasible.

PROF. CHAS. MAYR (Chicago Fire-Proof Covering Co.): I just heard a very important question, namely, whether increasing the thickness of a covering by 30 per cent. would result in a corresponding greater saving. The trouble is that covering of the thickness tested, of about $1\frac{1}{2}$ inches saves over 90 per cent. of the loss from the covered surface; if the thickness is increased ever so much there can only be effected the loss of 100 per cent. minus 90 per cent., or only 10 per cent.; hence, 30 per cent. increase in thickness would, at the most, increase the saving 4 or 5 per cent. Even if the covering is made ten feet thick, and saved 99.9 per cent. there would result for 800 per cent. increase in thickness only 9.9 per cent. saving. It becomes a question of expense; when a covering is $1\frac{1}{2}$ inches thick and saves 90 per cent., an increase by $1\frac{1}{4}$ inches would save, perhaps, to 93 per cent., but it would be questionable whether the value of the saving would compensate for the cost of the increased thickness. $1\frac{1}{2}$ inches is pretty nearly the maximum thickness for saving as compared with the greater cost of increased thickness.

I have here a copy of the table accompanying Mr. Marshall's discussion, but I cannot agree with the vital reason for guessing figures which bring out D so prominently ahead and all the others way behind in the rabble. Mr. Marshall says: "The standing condensation per minute is taken at figures '*believed*' to be more consistent than those derived from tests." Gentlemen, is "belief" worth anything when opposed to facts? Nobody accepts belief where he can have facts. Just look at it. D is given a condensation of $5\frac{1}{8}$ pounds per minute, while E and F have 5.27 pounds alike, and

C and B are way down in the ruck. D's superiority is not based on any arithmetic, but on the elegant calculation that "the standing condensation per minute is taken at figures '*believed*' to be more consistent than those derived from the tests." Is that science, gentlemen? By "belief" we can prove anything.

There is a point on which I have to compliment the gentlemen who made the report; it is a remarkable and difficult feat, namely, the extreme care with which they avoided giving offense to any covering maker; the figures are given correctly, but in everything which might influence the results, the conclusions say: Oh, there is very little difference; the differences can be neglected; the wind was very light compared with the train speed, etc. In order to show themselves very, very careful they keep saying: There is no difference; or, the difference is unimportant. Take the figures in the report; one covering saves 64 per cent., another 60 per cent., a difference of 4 in 60 is 7 per cent. Now 7 per cent. of \$600, the annual total heat loss of a bare boiler, is \$42.00. Why, I don't save that in two weeks. That \$42.00 is as much as the cost of any covering put on. But the report calls all these differences trifling; the gentlemen are over-sensitive. Now as to the standing test. All the gentlemen at Clinton remember that the locomotive stood in the level yard; there are no sheltering, towering mountains at Clinton; the wind was blowing all about the locomotive. What is called standing test is really a test with the engine in motion, running with the speed of the wind at the test. That running test was called standing test. If the wind blows with ever so light a velocity against an engine standing in the yards, that engine cannot be considered standing, in regard to heat losses effected by that wind. The heat losses are solely produced by air currents swarming about the locomotive. If a locomotive could carry its own air in a cab while running, there would be very little heat lost. Therefore, no standing tests were made.

In five passages in the paper, it is said the wind was negligible. Now, if riding in an engine, traveling twenty-eight miles per hour, we go *against* a wind of only sixteen miles per hour, as one case in the test shows, it is the same as if we traveled in a windless atmosphere with a train speed of twenty-eight plus sixteen, or forty-four miles per hour; and, if we travel *with* the same wind of sixteen miles, the effect is precisely as if we traveled in a windless atmosphere with a net speed of twenty-eight minus sixteen, or twelve

miles per hour. Between forty-four and twelve there is no "negligible difference;" the first is nearly four times more than the second, or 280 per cent. greater.

If we move with twenty-eight miles, we condense in a bare boiler fourteen pounds per minute, or for one mile, as 6.7 pounds are lost "standing" when we move with no speed, we lose fourteen minus 6.7 divided by twenty-eight, or about 0.26 pounds (one-fourth pound a minute) per mile an hour speed. Therefore, going against a wind of sixteen miles, we have a total speed of twenty-eight plus sixteen, or forty-four miles, and a loss of $6.7 + 44 \times 0.26 = 19.1$ pounds; and, if moving with this wind, a loss of $6.7 + 12 \times 0.26 = 10.0$ pounds, or a difference of nine pounds; not at all "negligible."

This wind effect explains most of the difference between D_1 and D_2 ; both were made of the same material; D_2 was $\frac{1}{8}$ -inch thicker than D_1 ; but D_2 had to go against wind while D_1 was by far the most favored by wind of all the nine runs. It had a wind from the rear on three-quarters of its runs; all others had it on two, with exception of E, which had head wind twice as heavy as D_1 on three-quarters. Also F_1 had, on the day I watched it, very high and flanking wind. A flanking wind is more difficult to figure; its effect may be even more than a straight head wind. I find it can be figured nicely, if you use a little trigonometry and split it into components by the sine and cosine rule. By thus figuring the wind I found that E and F_1 suffered most by wind to amounts not at all negligible.

The "standing test" of the bare boiler was unfortunately made in a ten-mile wind, and therefore we can only reach the true figure by allowing proper corrections for the wind.

By taking the figure 0.26 pounds (more correctly 0.28 pounds) of water condensed per minute per mile (hour) speed of bare boiler, in addition to the standing loss, and multiplying it by the loss per cent. of each covering, about 40 per cent., we obtain a figure .112 pounds, about one-ninth of a pound, for the covered boiler as condensation per minute for every mile wind or train speed per hour, which allows us to correct and account for all variances in the table, by adding the wind or train speed effect to the standing loss figure.

MR. ROBERT QUAYLE (C. & N-W. Ry.): Professor Mayr, in his remarks, criticises statements in the paper to the effect that the wind was "negligible;" had the tests been made with the train moving in only one direction the effect of the wind might have been con-

siderable, but with one-half of the run made in one direction, and the other half in the opposite direction the effect of the wind was in a large measure neutralized. This is more particularly true when the wind was constant, and was a "head wind" for one-half of the trip which made it a rear wind for return trip. Furthermore, as the tests were made in summer and all the winds were light and did not differ greatly for the different laggings tested, it was concluded that they might fairly be considered negligible.

MR. A. D. MORRIS (H. W. Johns Mfg. Co.): I think this test is one of the most valuable ever made of locomotive boiler coverings. It is of the utmost importance to railroad men because it has developed to them a greater saving than they could obtain by the same expenditure in any other line. I believe that when they find that the locomotive boilers, without a covering, lose by the condensation as much steam as this boiler did, and that they can reduce that with a slight expenditure of money, they will seek whatever will give them the greatest returns. I consider this test of the utmost value to railroad men, and that they will be benefited dollars where the manufacturer receives cents.

Before the discussion on the subject is closed it should be explained that, in the case of two of the coverings, after the first run was made with each, and the jacket was removed, moisture was found on the outside of the lagging and a second test was made with each. In the case of D_1 it was considered best, by the manufacturers, to apply a fresh covering of the same material and thickness, but in handling, to facilitate the drying process, it is probable that the slight increase in thickness, which is reported, resulted from such handling. This second covering is designated D_2 .

MR. W. H. MARSHALL: Professor Mayr has criticised the table presented in connection with my discussion, because of the fact that I have assumed a certain rate of condensation for standing tests. I think the reasons for making these assumptions are clearly stated in my contribution to the discussion, and, furthermore, I still believe that the assumption was justified, and fair to all the laggings. I am aware that presenting a table in which several assumptions have been made does not, on the face of it, bear the stamp of scientific accuracy, and yet I believe that such a method of investigating the results actually obtained during the test is actually necessary in order to realize the full value of the experiments. I might add by

way of explanation that the column headed "D" in my table is an average of D_1 and D_2 appearing in Mr. Quayle's paper, and that column "E" is an average of E_1 and E_2 .

MR. A. M. WAITT (L. S. & M. S. R. R.): In view of the great courage and successful efforts of our friends here to translate these Greek hieroglyphics, I think it may be desirable for those who are not here this afternoon to have the benefit which we have gleaned here. I think there are no more valuable reports for the benefit of railroad men than those that have been compiled by the Master Car Builders' Association committee on brake shoe tests, where a spade has been called a spade, where the names of the different articles and the tests were made known in plain English, and I think it is a mistake sometimes to show too much modesty in stating the actual results of the tests, and what the articles are that are used. I have in mind a test that was made by the Master Car Painters' Association during the last year, and the tests published are absolutely valueless, from the fact that simply the materials that were used were mentioned and no names, and some of the paints that have the same materials in them were bad and some were good, so that there was no value in the reports. It may not be the sense of this meeting, but I venture a motion to this effect, that it is the sense of this meeting that Mr. Quayle consent to have the report published with the names of the different laggings that were used.

THE CHAIRMAN: I will not put Mr. Waitt's motion until Mr. Whyte has made the closing remarks.

THE SECRETARY: You may have uppermost in your minds the question of wet lagging, and I wish to reply to that first. It is not understood that any one of the laggings was wet. No one of the laggings was wet in the sense in which you may understand that word, but all lagging will carry more or less moisture, and, except the cement lagging, every lagging presented for test contained more or less moisture in such amounts as not to show until after the boiler on which it had been placed had been heated. When the steam was turned on the boiler, that part of the lagging next to the boiler was dried out first, and the moisture driven from that surface through to the jacket the steam became cool and condensed, and the jacket being tight the water or steam could not escape and therefore settled in the lagging next to the jacket. This was considered a normal condition.

Mr. Soule has suggested that there must have been something in

common to all the laggings which made them all show so nearly alike, and suggested that perhaps it was the air cells, or the air entrapped in the lagging. I think it has been brought out quite distinctly that it was the thickness of the covering that was common to them all. It is not the one large air space that will best prevent the passage of heat, but the air must be entrapped in small, sealed cells, so as to require the heat to pass from one substance to the other, and the greater number of times such transfer of heat takes place, the better the insulation.

In regard to publishing the names of the manufacturers, Mr. Quayle is entirely agreeable to this, but it rests with the manufacturers. Before the tests began, it was understood that the results of the tests would not be published without Mr. Quayle's consent. That was leaving quite an important decision to Mr. Quayle's discretion; but the manufacturers agreed to it before the tests began. Mr. Quayle deferred to their wishes, however, in not giving the names because some of the manufacturers so requested. Some of the manufacturers were preparing to publish the report, although not giving the names of the coverings, and Mr. Quayle felt that he could present the paper to the Club without giving the names and not transgress on his agreement; but if the manufacturers are willing, Mr. Quayle is willing to give the names.

THE CHAIRMAN: It seems to me, that, aside from any matter of opinion as to whether names should be published, the paper itself contains evidence upon which we may safely rely. Mr. Quayle has stated plainly that the results given are not strictly reliable for purposes of comparison; the work was not designed to give a high degree of refinement in the measurements taken. It would, therefore, seem unwise to affix values to individual products when the relative standing of these values is plainly open to doubt. Mr. Quayle has exercised excellent judgment in refraining from affixing names to these values.

MR. DELANO: I think that, because reports of this kind are referred to frequently in the future, it would be of great importance *if* the names of the manufacturers are not to be given to have, somewhere in the paper, in an appendix, for instance, the description of the forms of lagging tested. They need not be identified with the letters, but any one reading this report and not having been told, might easily suppose that the ordinary wood lagging, once common

in the United States, was one of those tested. If he happens to be here at this meeting, he sees samples of all the lagging, but these cannot appear in the paper, and it seems to me that a description ought to appear.

THE CHAIRMAN: I will ask Mr. Waitt if he desires to renew his motion.

MR. WAITT: I think that with the paper as presented, we ought to have as much data as possible, in order to have the value of it, not particularly for those who are here, but for those who are not here. I think the paper would not have been presented unless it was considered by the author to have some value on account of the different data which was considered desirable to distribute, and that others might receive a benefit therefrom, and I would like to renew the motion. It may not be the sense of this meeting to carry the motion, but the motion is, that it is the sense of those present that Mr. Quayle be requested to publish in the Proceedings the names of the different kinds of lagging.

MR. RHODES: It might seem at first that there is a great deal of argument why we should know the names of the different materials tested, but there is another feature of this question: What is it that makes clubs successful? Is it the members who stay away, or is it the members who attend the meetings? Do those who present papers, or those who do not present papers, make the club a success? We can insist on having at these clubs and at our associations papers presented in such a way that there will be fewer and fewer papers presented, and we can also conduct our business in such a way that we will get some papers which otherwise we will not get. I have been connected with various reports and various papers presented to our associations, and at times it has been quite embarrassing to present the facts just as they appear. I believe that sometimes it is a good thing to present facts without designating definitely the different interests that may be involved. Take, for instance, here—we know now, without any difficulty, the principal names of the laggings that are presented; we did not know it when we began the meeting. That is one of the advantages we have gained by attending this meeting, and I am of the opinion that it will rather hurt reports and hurt the clubs if, when certain of our members present papers, we insist on having published in the Proceedings the names of devices which, to some extent, the papers criticise and which may after-

wards bring about questions, letters and correspondence which otherwise might be avoided. I think Mr. Waitt's motion is all right, leave it to the discretion of Mr Quayle—and I hope that when the resolution is presented to Mr. Quayle he will decide not to publish the names.

MR. TODD: As a manufacturer, I have refrained from making any extended remarks relative to this test that was made at Clinton, waiting for this very meeting, so that the report would be brought out before the Western Railway Club. If a covering were in that test and it showed up well there will not be, probably, a railroad in the country but what will know of it. The manufacturer whose covering showed poorly will make excuses and they will be known. One way or another it will be discovered which covering each one is, whether good or bad, because the one whose covering was tested and showed up detrimental to his goods will give a reason for it, which, in his opinion, can be deducted from the report, and I think it will be only a short time before it is known to all whose make each covering is.

The motion of Mr. Waitt was then put to vote and carried.

TOPICAL DISCUSSION.

Height of Drawbars; Recommendations to be made to the M. C. B. Association.

THE CHAIRMAN: The subject for topical discussion is found on page 113 of the December Proceedings. The Secretary will read a statement of the subject.

THE SECRETARY: A communication came from Mr. Barr, transmitting a communication from the Joint Car Inspection Association at St. Louis, and is as follows:

ST. LOUIS, MO., November 22, 1898.

SEC'Y J. C. I. ASS'N.

Dear Sir:—At a meeting of the Joint Car Inspection Association of St. Louis and East St. Louis, held this date, we were instructed to communicate with each Joint Association in the United States and ascertain if the other Joint Associations would join this Association and make request as one body on the Master Car Builders' Association, to place the following before the Interstate Commerce Commission with the view of having said Commission make railway companies not subject to fine on high and low drawbars, under the following conditions:

First: A car delivered in interchange by one railroad company to another railroad company with drawbars not in conformity with the Interstate law, the receiving line be allowed to handle such car to its repair track at point of interchange, for the purpose of adjusting drawbars to conform to the Interstate law, without prejudice against such receiving railroad company for moving car.

Second: A car delivered in interchange by one railroad company to another railroad company with drawbars not in conformity with the Interstate law, the receiving railroad company be permitted to handle car to its transfer track at point of interchange for the purpose of transferring contents of car and return such car when empty, to point of interchange, without prejudice against such railroad company for so moving car.

Also request that the Interstate Inspector be required by the Interstate Commerce Commission, to not report cars high or low, found in any railroad company's yards until Inspector is thoroughly satisfied that track on which such high or low car is standing, is in proper line.

Will you kindly present this paper to your Association at the earliest possible time and return us an answer?

Yours truly,

ED. SWINEFORD, Secy.

THE CHAIRMAN: The question is before you.

MR. PECK: I do not see much in that to conflict with the law, as

I understand it. The law and the M. C. B. rules provide that a car may be repaired and a bill rendered to the owner; certainly the transfer company cannot repair the car while it stands on the receiving track; the car must be taken to the repair track. I do think that the law will not require anything different.

MR. RHODES: Mr. Chairman, this is a matter on which much can be said if we want to get into an argument. I think that it would be profitable to pass a resolution to the effect that it is the sense of this Club that it is not expedient for the Western Railway Club to join in the proposed communication to the Interstate Commerce Commission, and offer this as a motion. (Seconded.)

MR. DELANO: I think that Mr. Rhodes' remarks are very wise, and it seems to me that we may say that, because the foundation of all law is common sense, it would not be good law to expect that a railroad company which is receiving a car fitted with drawbars contrary to the regulations of the Interstate Commerce law shall not be allowed to make repairs in the best way and the only way possible. It would be a quibble to suggest that the railroad company would not be allowed to handle a car unless the drawbar had been raised. It stands to reason, it seems to me, that any receiving company would be allowed to take such cars to its repair track and adjust the drawbar properly. I think, as Mr. Rhodes says, to call the attention of the Interstate Commerce Commission to any such simple and perfectly self-evident requirement would be quite unnecessary.

MR. R. D. SMITH (C., B. & Q. R. R.): The question, or one part of it, rather, seems to me to be a criticism on the methods used by the Inspector of the Interstate Commerce Commission, who, I believe, is not here, and I would like to defend the methods that he employs in measuring the heights of drawbars. I have gone with him twice through our yards at Chicago, measuring cars; the last time that he called on me he said that his method had been criticised at one point on our line. So before we started he asked me to measure his gage, or rather to assure myself that it was of the proper length. I told him that I thought it was unnecessary, but I measured the gage and was quite satisfied with it. Starting out through the yards, we passed string after string of C., B. & Q. cars which he did not seem to care to measure, leaving them, as I supposed, to be measured in the yards of some other company.

Among our cars that stood on our tracks were twenty-five to

thirty refrigerator cars, belonging to a private line, that were newly turned out of the Wells & French shops. We walked past five or six of these cars, when he asked me to measure the height of the drawbars on some of them. We measured two cars at both ends, after which he asked me if I were satisfied with the measurements taken and the track on which the cars stood. I told him I was entirely satisfied with the manner of taking both measurements, and he said that he would take exceptions to the height of those cars. We continued our trip, measuring in that train some half a dozen cars only; he might have reported all the cars in that train as being too high, because they certainly were too high. We measured other cars in various yards at different times of the day, and every time he asked me if I were satisfied with the measurements taken. In none of the cases did he take the measurements himself, but asked our chief inspector, who was with us, to take them. I looked at the gage each time a measurement was taken, after which the Interstate Commerce Inspector would put down the reported height when it varied too much from the limits.

He measured only those cars, the drawbars of which he found to vary considerable in height; that is, in cases where cars were coupled together and one drawbar was much higher or lower than the other, he would measure, perhaps, both of the drawbars. I speak of this because the question seems to me to be an unjust criticism of the Inspector's method of measuring cars, because I know that while with me he was entirely fair in every measurement that he took, and in every case that he reported he gave us the benefit of the doubt.

MR. DEEMS: I had, a short time ago, an experience similar to that cited by Mr. Smith and I want to emphasize what Mr. Smith has said. I believe that the Inspector for the Interstate Commerce Commission is much more liberal and more reasonable than some of the railroad inspectors are when making decisions affecting different railways.

The motion offered by Mr. Rhodes was voted upon and carried.

COMMITTEE'S REPORT ON M. C. B. KNUCKLES.

THE CHAIRMAN: Our second subject for topical discussion concerns the report and letter sent out by the committee on couplers,

which letter is published in the December Proceedings, beginning on page 105. Mr. Delano will state the substance of the letter to which reference is made.

MR. DELANO: Mr. Chairman, I went into this letter pretty thoroughly at the last meeting, and it seems to be wasting the time of the Club to repeat what I said at that meeting. I want to say that at the next meeting of the Club the committee will hope to offer something in the way of further report of progress, and to exhibit a gage suitable for use in gaging M. C. B. couplers in the manner indicated in this letter, and in the discussion at the last meeting, namely: A gage which shall go further than the old M. C. B. gage; that shall extend sufficiently far to define the length and the form of the point of guard arm. It should also be a gage referred to the axis of the shank of the guard arm. I want to repeat, also, that we would like to have suggestions and criticisms from the makers of couplers. This letter was sent to prominent manufacturers, but it was not sent to every one, and the printing of the letter in the minutes was in order that it should reach all members of the Club. I hope the manufacturers will not be "backward in coming forward" if we have done them an injustice in the classification, which was simply a tentative one. And, again, if they have suggestions to make in regard to this gage of which I have spoken, we wish they would make them. Suggestions made before the report is submitted in March, will be of more value than suggestions made thereafter, and I think that no one can feel aggrieved after having had two or three months' time in which to make suggestions, if he finds that he has been overlooked as a result of his silence.

Adjourned.

THE EXCURSION.

One hundred and one was the number which joined the party at Chicago on the evening of January 17, 1899, which journeyed that night to Hamilton, Ohio, to visit the shops of the Niles Tool Works Company, and others joined the party at various places, in numbers sufficient to make the total at Hamilton about 150. The excursion was directly in the care of Mr. Geo. F. Mills, manager of the Chicago branch, and Mr. A. L. Guilford, also of the Chicago office of the company. Four sleeping cars were provided, and everything was

so excellently managed that everybody was extremely well satisfied. The route was over the "Monon." Arriving at Hamilton, breakfast was found waiting in a new erecting shop, which had not been fitted with tools, and luncheon and a banquet came in their turn. The entire day was spent at the works of the Niles company and every facility was given for a thorough inspection of the shop equipment, the methods of doing work and the work in course of construction. After the banquet and concert, it devolved upon Mr. A. M. Waitt to thank the officers of the Niles Tool Works Company for the opportunity presented to obtain much information and for the very royal entertainment. Responses were made by Mr. R. G. McKinney, general manager, Mr. Jas. K. Cullen, secretary, and Mr. Mills, of the company. Mr. J. F. Deems and Mr. J. F. Lewis ably seconded the sentiments expressed for the party by Mr. Waitt. Returning, the party arrived in Chicago Thursday morning, January 19.

The names of those who took advantage of the excursion follow :

Geo. W. Scott	J. W. Hill	W. G. Wallace	E. D. Bangs
Peter H. Peck	J. White	John T. Carroll	E. C. Cummings
A. M. Waitt	J. F. Deems	B. Reiley	J. C. Whitridge
D. Hawsworth	G. F. McKee	J. M. Hopkins	R. T. Shea
A. Monkhouse	John Gordon	J. E. Keegan	Gustav Giroux
R. D. Smith	Alex. Shields	M. S. Connors	W. H. Woodruff
J. B. Barnes	Wm. Garstang	Wm. H. Goehrs	W. H. Elliott
F. Slater	H. K. McLean	T. L. Condron	A. M. Castle
C. L. Elmes	W. C. Halfman	E. D. Wileman	W. P. Coburne
W. F. Bradley	E. E. R. Tratman	B. J. Neeley	C. R. Gilman
Thos. W. Capon	H. T. Ayers	W. R. Ellis	G. A. Woodman
Wm. Hutchison	W. H. VanDervoort	P. A. Murphy	H. O. Westmark
Mr. Thompson	W. J. Hahn	Jos. Buker	H. H. Swift
Mr. Ringi	W. J. Hess	J. A. Cohen	C. B. Duffy
E. R. Stettinius	Mr. Doyle	F. H. Clark	C. B. Nicholson
A. B. Stetson	W. S. Canright	H. T. Bently	T. R. Morris
Wm. H. Edgar	Wm. McIntosh	N. O. Whitney	Thos. Andrews
E. G. Elcock	R. Wharton	E. G. Taylor	A. T. Perkins
Chris. Scholtka	W. W. Butler	G. P. Nichols	C. E. Slayton
W. A. Hance	G. S. Slaughter	Sanford Keeler	J. C. Anderson
T. B. Kirby	Theo. W. Snow	A. D. Morris	Mr. Low
F. W. Wolf	J. C. Williams	J. A. McRae	W. E. Elliot
Mr. Diedrick	E. P. Armory	R. S. Wickersham	John Tonge
A. W. Goodrich	W. O. Davies	H. R. Cuths	E. S. Greusel
C. Weatherson	John P. Neff	H. T. Schroder	W. G. Starkweather
John Foulk	Elias Hedrick	E. F. Jones	J. R. Nichols

C. H. Osborne	Mr. Shiffin	John McMynn	Wm. Lovergan
W. S. Jacoby	E. S. Jackman	Geo. F. Mills	Mr. Elmer
Wm. Mohr	J. N. Reynolds	A. L. Guilford	R. W. Bushnell
John Fultz	Mr. Stiffey	T. W. Edmunds	Wm. Hewitt
J. F. Lewis	Mr. Connors	G. B. Abbott	O. W. Guldlin
T. F. Barton	Mr. Guy	Al. Mohr	Chas. Cory
J. M. Taylor	Samuel Otley	F. E. Paradis	J. R. Maxwell
Jas. Gardener	Chas. L. Gateley	J. R. Cardwell	Joseph Long
H. Moore	Wm. Miller	Mr. Medawy	Mr. Smith
Mr. Sprague	M. N. Scott	P. Plantinga	

THE DAVID L. BARNES LIBRARY.

SPECIAL NOTICE ! The David L. Barnes Library of this Club, at 1750 The Monadnock, Chicago, is open for the use of members and their friends, and we hope it will be used freely. It is open on week days from 9 a. m. to 5:30 p. m., except on Saturday, until 3 p. m. Books must not be removed from the Library, but the librarian will assist visitors in finding information and will promptly reply to letters from out-of-town members desiring information from the Library. Donations of books and technical publications will be gratefully received.

TRUSTEES OF THE LIBRARY.

List of duplicate copies of the Proceedings of the Western Railway Club which are in the David L. Barnes Library and are for sale or exchange:

1888—Sept. and Oct. (bound in one).

1889—Oct., Dec.

1890—Feb., Sept., Oct., Nov., Dec.

1891—Jan., Mar., Apr., May, Oct., Nov.

1892—Jan., Feb., Apr., May, Sept., Nov., Dec.

1893—Two complete volumes; also single copies of Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

1894—Jan., Mar., Apr., May, Oct., and Index of subjects discussed by the Club.

1895—Jan., Apr., Sept., Oct., Nov., Dec.

1896—One complete volume, also single copies of Jan., Mar., May, Sept., Nov.

1897—Jan., Feb., Mar., Apr., May, Sept., Nov., Dec., also two complete volumes.

1898—Jan., Feb., Mar., Apr., May.

Correspondence relating to the Library, donations of books, periodicals, etc., for the files, or duplicates sent for exchange should be addressed to H. de K. Woods, Librarian, 1750 Monadnock, Chicago.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED, April, 1884.

INCORPORATED, March, 1897

FEBRUARY 25, 1899.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 6.

CHICAGO, ILL.

\$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Roadmaster, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER.	JOHN W. CLOUD.
F. W. BRAZIER.	H. G. HETZLER.
PETER H. PECK.	F. W. SARGENT
PROF. WM. F. M. GOSS.	

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio.

The regular monthly meeting of the Western Railway Club was called to order at 2 p. m. Tuesday, February 21, 1899, in the Auditorium Hotel, Chicago. Vice-President, F. W. Brazier, in the chair.

Following are the names of those who registered:

Amory, E. P.	Hatswell, T. J.	Peck, Peter H.
Anderson, Geo. T.	Hedrick, Elias	Pflager, H. M.
Anderson, Thos.	Horrigan, J.	Raidler, W. P.
Angell, F. R.	Jacoby, W. L.	Rennolds, W. C.
Blanchard, W. A.	Johann, Jacob	Riddell, Chas. H.
Borton, C. C.	Johnson, A.	Sanborn, J. C.
Brazier, F. W.	Keegan, J. E.	Sanborn, J. G.
Bryant, W. E.	Keeler, Sanford.	Sawyer, E. C.
Church, H. L.	Kerr, Prof. C. V.	Scales, R. P.
Clifford, C. J.	Kirby, T. B.	Shea, R. T.
Conger, C. B.	Kuhlman, H. V.	Smart R. A.
Cook, E. E.	Lane, F. W.	Smith, L. L.
Cooke, W. J.	Lawler, F. M.	Stark, F. H.
Cooke, Jas. W.	Mackenzie, Jno.	Streeter, A. L.
Crosman, W. D.	Mason, Geo. G.	Sullivan, C. L.
Cushing, Geo. W.	Medway, Jno.	Traver, W. H.
DeWolf, J. O.	Mileham, C. M.	Whipple, A. L.
Feldman, Prof. A. M.	Miller, Wm.	Whitridge J. W.
Fildes, Thos.	Molleson, Geo. E.	Whyte, F. M.
Forsyth, A.	Noble, L. C.	Wickhorst, M. H.
Gardner, J. W.	Otis, Spencer	Williams, J. C.
Giroux, G.	Paxton, Thos.	Woods, J. L.
Graham, J. A.	Parisoe, Louis	

THE CHAIRMAN: In the absence of the President it becomes my duty to preside. The minutes have been published in the regular Proceedings, and if there are no objections, they will stand approved. Hearing none, they are approved as printed.

The next order of business is the announcement of new members.

The Secretary then read the following names:

Mr. D. D. Carothers, Eng. M. of W., B. & O. Sw. Ry., Cincinnati, Ohio.

Mr. Edwin G. Chenoweth, General Machinist, C. & E. Ry., Huntington, Ind.

Mr. J. D. Coffey, Road Foreman of Engines, A. T. & S. F. Ry., Fort Madison, Iowa,

Mr. J. O. De Wolf, Boston Woven Hose and Rubber Co., Cambridgeport, Mass.

Prof. A. M. Feldman, Associate Prof. Mech. Engineering, Armour Institute of Technology, Chicago.

Mr. J. A. Graham, M. M., C. L. & W. Ry., Lorain, Ohio.

Mr. John Hair, Div. M. M., B. & O. Sw. Ry., Chillicothe, Ohio.

Mr. F. W. Hornish, Hornish Mechanical Boiler Cleaner Co., Chicago.

Mr. D. F. Jennings, Revere Rubber Co., St. Louis, Mo.

Mr. Herbert E. Kyger, Loco. Engr., C. & A. Ry., Bloomington, Ill.

Prof. C. V. Kerr, Director Dept. Mechanical Engineering, Armour Institute of Technology, Chicago.

Mr. Ira B. Lesh, Supt. Fort Madison Iron Works, Fort Madison, Iowa.

Mr. D. R. MacBain, Trav. Engr., M. C. R. R., Jackson, Mich.

Mr. Geo. F. Mills, Mgr., Niles Tool Works, Western Union Bldg., Chicago.

Mr. H. I. Miller, Supt., T. H. & I. R. R., Terre Haute, Ind.

Mr. M. A. Tougher, Clerk, B. & O. Sw. Ry., Washington, Ind.

Mr. J. Murray, Canadian Pacific Ry., Winnipeg, Manitoba.

Mr. W. H. Nuttall, S. M. P. & R. S., Manistee & Northeastern Ry., Manistee, Mich.

Mr. E. H. Stark, M. C. B., C. L. & W. R. R., Lorain, Ohio.

Mr. E. P. Thomas, Revere Rubber Co., 38 So. Canal St., Chicago.

Mr. W. P. Whiting, Mgr. Chicago Store, Hill, Clarke & Co., 14 So. Canal St., Chicago.

Mr. Howard L. Whitlock, Draftsman, Rich. Loco. Works, Richmond, Va.

Mr. Wm. Wright, General Foreman, Vandalia Line, Terre Haute, Ind.

THE CHAIRMAN: Mr. Delano, has the committee on couplers a report to make?

MR. DELANO: Your committee have nothing very interesting to report; they submit their report of progress:

Your committee on the subject of M. C. B. couplers is not ready to make its final report, but hopes to make such report at the April meeting of the Club. As a matter of interest to members, we have made a revised table, showing couplers classified by groups according to use.

Group I shows the M. C. B. couplers, of which there are more than 10,000 in use.

Group II. shows the couplers of which there are less than 10,000, but more than 1,000 in use.

This table cannot be said to be up to date, in that it is taken from the latest report of the statistician of the Interstate Commerce Commission, for the year ending June 30, 1897, and it is but fair to say that some of the couplers shown in Group II, have advanced into the class shown in Group I, and that some couplers not shown in either group might be named. In a general way it is certainly a fair statement of facts. Group I includes nine different couplers, seven of which are in prominent use to-day. Group II includes twelve couplers, but the use of eight of these couplers is confined largely to the section of country where they are manufactured. There are seventy-nine other couplers shown in the report of the statistician of the Interstate Commerce Commission, and which are not named. They would form Group III.

It will be the effort of your committee to show in its final report, wherein even the prominent manufacturers have departed from the original lines laid down by the M. C. B. Association, in some cases actually deviating from the

contour lines, and in almost every case by ignoring the center lines laid down by the M. C. B. Association. There can be no question but that many of the faults to which couplers are heir could be eliminated if coupler manufacturers were required to make their new couplers conform accurately to the original M. C. B. standard. It is probably also advisable for the M. C. B. Association to carry the safety limit for guard arm something like three-fourths of an inch beyond its present termination.

F. A. DELANO,
J. N. BARR,
JOHN MACKENZIE,
PETER H. PECK,
THOS. FILDES,
Committee.

GROUP I.—10,000 or more in use.	GROUP II.—Less than 10,000 and more than 1,000 in use.
NAME OF COUPLER.	NAME OF COUPLER.
American. Buckeye. California. Chicago. Gould. Janney. Standard. Trojan. Tower.	Dowling. Hien. Hinson. Janney-Buhoup. Lone Star. Mather. Pooley. St. Louis. Shickle, Harrison & Howard. Smilie. Thurmond. Van Dorsten. Williams.

THE CHAIRMAN: The next order of business is the reading of the papers, "The Uses of Compressed Air About Railway Shops," by Mr. J. W. FitzGibbons, Mr. Willis C. Squire and Mr. B. Haskell.

THE USES OF COMPRESSED AIR ABOUT RAILWAY SHOPS.

BY MR. J. W. FITZGIBBONS.

Compressed air, as a means of power transmission and distribution, has, in the past few years, become an almost indispensable adjunct of a railroad shop. Its extreme flexibility and ease of general adaptation has opened up to the shopman a remarkably wide field of invention, which he has not been slow to recognize, and to make use of. The lessening of the expense of operation, and the eliminating of the necessity of manual force, has in many cases been the result of the general adoption of air power. A glance around a modern railway shop would almost convince the uninitiated, that air had nearly, if not completely, filled its wide field of usefulness. The motor takes the place of the wrench and ratchet, the air hoist the place of the gang of men with jacks and bars, the blower supersedes the broom, the paint sprayer out-classes the brush and the pneumatic hammer puts the old hand hammer back in the tool box in many instances. And still new contrivances for air are continually being announced. A prediction of far greater uses of this power distributor, than have already been investigated, would hardly seem inappropriate.

The air hoist, of all sizes and lifting powers, was one of the first ideas to be experimented with. This apparatus is used to lift engine driving wheels in and out of the drop pit, to facilitate the handling of wheels and axles at the press, to handle heavy work around drill-presses, lathes, boring mills, benches, and in fact at all points where heavy lifting is necessary. With a properly designed and arranged hoist, one man can accomplish as easily and speedily, what a gang of men was formerly required to do.

In our outline we will confine ourselves to the experiences and results obtained at the Horton shops, of the Rock Island railway. Here a fairly general use of air is made. Direct-connected compressors, of home construction, are attached to the car shop, and the "back" shop stationary engines. By these, air is compressed into the reservoirs to a pressure of 100 pounds per square inch. The system of supply piping extends through all the buildings, and also through the yards. The various outdoor hoists, and the "rip" and paint tracks of the car shop necessitating this rather extensive arrangement. Both reservoirs are so piped as to supply together the entire system or their separate sections alone.

For general use through the yards, hoists are placed. Convenient to the "back" shop and roundhouse a double hoist is situated. It has two sixteen-

inch cylinders, each swinging from dolly cars, free to travel over the center of the track, for one-half of the twenty-foot span of the frame work. This hoist is in almost constant use, unloading boilers, broken trucks, etc., from flat car, removing and replacing tender tanks, and doing all such heavy, general lifting. The two cylinders are arranged to work together or separately. The advantages of this plan are found in handling long, large work, while for smaller work, of course, only one cylinder is operated. At the casting pile, a twenty-inch cylinder is swung from a nineteen-foot traveling crane, which covers a space fifty feet long. This is used to handle locomotive driver tires, driver centre castings, cylinder castings, engine truck centre castings, and all such heavy and cumbersome material.

For loading and unloading mounted car wheels, smaller hoists are used. These are of the crane type, in which a wire cable runs from the cylinder placed next to the mast, over pulleys at each end of the boom. Over three of the car repair tracks, a hoist is arranged which does the heavy lifting needed in this kind of work. The car track pit is also supplied with a hoist, which can be used over any point in the entire length of the pit. The ease and safety with which large weights can be handled with these hoists, is only appreciated by those who have adopted them for general use.

On the tool-room bench drill of the rotating piston type fitted up as a drill press, is a machine well worth the investment. For drilling holes as large as one-quarter inch in diameter, in any metal, its usefulness is unsurpassed, and considerable time is saved the benchman by not having to wait for the work to be done at the regular drill press. Another handy tool-room device is a simple blower, consisting of a piece of three-eighths-inch pipe, about eighteen inches long, with valve and hose attachment at end, and suitable nozzles at the other; this blower is used to clean all sorts of work which comes to this place for repairs. Especially is this of advantage in repairing hydraulic jacks.

Air used in place of steam in the small engine used for driving the valve-seat facing machine, has its evident advantages. Hand motors are universally used for drilling in the engine-erecting and repair shops. These same motors are also used in rolling flues, tapping out staybolt holes, and in screwing in the staybolts. A very uniform tightening of the staybolts is the result of the last practice. Caulking and riveting tender tanks, caulking boilers, beading flues, and general chipping are examples, in the field of the pneumatic hammer.

Records are numerous for this tool, in all its various uses, which show results remarkably beyond the old practice with the hand hammer. A heavy hammer for striking upward blows, or for use as a "hold on" in any position, consists of a piece of brass pipe, in which is fitted an iron plunger. One end of the pipe is plugged, the other end open. The plunger head is made somewhat smaller than the diameter of the pipe, in order to give clear space for the burr which forms on the end of it. Air being admitted at the lower, or plugged, end of the pipe, the plunger is raised. If the apparatus is to be used as a hammer, a vent in the side of the pipe is opened. As the plunger shoots by this opening, the air escapes and the plunger drops back after striking the blow. Having closed the vent, it is again forced up for another blow, and so on

If a "hold on" is desired, the vent is simply closed. The plunger then rises as far as possible and remains rigid. A pneumatic bolt nipper is used for cutting off the projecting ends of staybolts, and a bolt puller removes, or breaks off, old staybolts.

As has been mentioned before, hoists are placed throughout the shop at convenient points, at the drop pit, the driving box press, the boring mill, the radial drill, the bed planer, the axle lathe, etc.

For the tinsmith an air punch is fitted up, which, with suitable dies, turn out stamped work, as well as doing the miscellaneous punching required in this department. Switch lamp tops, and, in fact, tops for all classes of railroad lamps are samples of the work done on this machine. Cast iron dies are used for this kind of stamping, these making the outlay comparatively small.

Around the car repair tracks two handy jacks are used; one is arranged for pulling down, and the other for raising. The former is used to remove bolts, sills and similar work; the latter is used to replace the removed member and also for heavy lifting. Both these jacks are mounted on three-wheeled trucks, making them convenient to handle and to put in place.

For cleaning coach seats an especially formed nozzle of the shape of a piece of pipe with one end flattened, is attached to the end of the air hose. It has an aperture about two inches long, and narrow enough to suit the work in hand. The dust and dirt are simply blown out of the cushion. Another use of the blower is in the cleaning up of the floor and machinery of the mill. A few dextrous applications of the air hose to a machine removes all dust and oil, doing a much better job than could be done by hand, and in much less time. All the inexposed parts are reached, and no dirt is left. This same statement applies to cleaning the floor; cracks and corners which a broom cannot reach do not fill up in time. A general feeling of cleanliness is evident after "blowing out" of the mill.

Paint-spraying machines operating on the idea of the injector have taken the place of the brush for all general surface painting. One style of machine, the larger, is mounted on wheels for convenience in handling. A long hose and a long iron pipe nozzle permit the painting of an entire car, with the exception of the roof, the operator standing on the ground. For smaller surfaces the machine is made small enough to hold in the hand; the hose and nozzle are dispensed with and the paint is sprayed direct from the machine. Freight cars, car trucks, engine frames, fire boxes, engine trucks, cylinder and steam chests are some of the parts which are painted by the machine. Walls of buildings are also painted, or whitewashed, with the same machines. In the hands of a skilled workman, the work can hardly be distinguished from hand work.

At roundhouses, where the sand dryer is not elevated, air is used to put the sand into the engine sand box. The dried sand is shoveled into a reservoir which is then sealed and air pressure being applied, the sand is carried along through the connecting pipes, up over the engine and into the box. A valve at the end of the few feet of hose, attached to the end of the piping, puts the control of the apparatus in the hands of the person who is filling the box on the engine. An old reservoir of any dimensions will do for this arrangement, a tank

nine feet long by three feet in diameter placed on end and filled nearly full of sand does as well as a small reservoir. About forty pounds pressure of air is needed for this purpose.

A practice followed in the "back" shop is to put a running gear of an engine together, and to take the engine to the paint shop running it by compressed air. Compressed air is made use of in hose fitting; this arrangement is a plant of itself, separated entirely from the general plant. On the car shop transfer table, in connection with the engine and boiler, there is a small air plant. A single air pump gives all the air needed. Clamps operated by air hold the hose, while air presses the coupling into place. Releasing the clamps, the hose is placed between another pair of clamps, also operated by air, which press the hose clamp into place and hold it there while the clamp bolt is tightened. Fittings are removed from old hose with the same apparatus, the operations simply being reversed.

USE OF COMPRESSED AIR IN THE SHOPS OF THE SANTA FE SYSTEM.

BY MR. WILLIS C. SQUIRE.

In our experience with compressed air on the Santa Fe system we have found it to be of such inestimable value in shop work, that it becomes a business proposition, and at every point on the system, where the installation can be made to advantage, we have put in a plant commensurate with the needs of the place. In this connection we do not assert that we are so far ahead of all our friends that we have nothing to learn, but we know that the extended use of this power has eliminated so many items of expense that the service is being constantly augmented by new devices. At our division points we have installed modern compressing plants so that we may secure the maximum efficiency with minimum expense under the conditions existing at such points.

We have found such a multiplicity of conditions existing in building up this part of the work that it is evident to ourselves a revision is necessary in the manner of accomplishing the initial work. We have in the past year secured some very large modern compressors for the more important division shops and transferred the smaller machines to the less important points, so that, at the present time, we have over the entire system a fairly modern outfit for compressing air.

The large and small tools for accomplishing the actual work being made in our own shops and after our own designs, has secured an uniformity of practice over the whole system, and the relative costs of doing the same work at different shops is determined by the efficiency of the compressing plants which supply the power. It is our practice, as far as possible, to make all air tools at Topeka shops, for at that point we are better fitted to do the work. Where the work can be done as cheaply at other points as at Topeka we furnish drawings, rough castings, finished brass work and small fittings.

The main shops being located at Topeka, we have probably the most diversified application of the use of compressed air than at any other point on the system, and at this point we have developed the use of this power to a very considerable extent. The experience gained here is given all other points for their mutual benefit. Where special tools are designed and perfected at points outside of Topeka, the results are carefully considered and, if found worthy, the device is made standard and placed at such points where their use will be of benefit to the service. The shops at Topeka, as before stated, being so well equipped with air tools, a short description of the plant will be in order, and will give some idea as to what is accomplished at that point.

Owing to the situation of our shops at this point, we have installed two

compressing plants, one for general use and the other for the boiler shops. The main plant is located in the car department engine room and consists of a duplex compressor of the following dimensions: Steam cylinders, 20 ins. x 48 ins.; air cylinders, 16 ins. and 28 ins. x 48 ins. Steam is supplied by a battery of three locomotive-type boilers in which we burn the refuse from the car shop and repair sheds mixed with which refuse is a small amount of low grade bituminous coal. Our fuel account at this point is extremely low, being so small that for the compressor we practically charge nothing to this account except for labor and interest on investment. These same boilers supply all steam needed for the engines in the car department and for other purposes. The exhaust steam is used for heating the dry kiln and shops in the immediate vicinity and from these points is returned to the condensers and feed water heaters, thus securing nearly all the work value contained in the steam. Owing to this arrangement, we are not able to determine exactly the bare cost of the power required for compressing the air. The compressors deliver air, under normal conditions, at 125 pounds pressure, but as the use of the air is equal to the supply, the average working pressure in the shops is about 100 pounds. From the compressors the air is delivered to ample receivers and condensers and then conducted by pipe lines to the remotest parts of the works in the yards. The compressor for the boiler shop is coupled in tandem with a large Corliss engine which supplies power for this department. This compressor is 12 ins. x 36 ins., and supplies air to the tools used in this shop alone; this makes the boiler shop plant independent of the other departments, which arrangement we find to be an economical one in our practice. We use no hydraulic machinery whatever in our boiler shop and consequently pneumatic tools are used exclusively. All our riveting machines, punches, rolls, furnaces, and large tools which are not driven by line shafting are operated by air. For small tools in this work are used the usual hammers for chipping and caulking and motors for drilling, reaming and tapping. Among the special tools, we have staybolt breakers and cutters, designed by our own men. The work done by hand is the flanging of sheets and such work as can only be done by laborers. Hoists and turntable jacks are used for heavy lifting.

In the car and erecting shops we have in use the usual jacks, hoists, turntables, drop-pits and motors, operating drills, saw-tables and small tools.

In the locomotive erecting shops we use special tools for milling the steam and exhaust ports, for valve setting and for boring cylinders. In the machine shops, we have special presses for forming standard tire and sheet metal shapes. In handling the scrap metal accumulating at Topeka, we have in use small steam hammers operated by air, bolt and iron cutters, and other special tools for straightening rods, bolts and round and flat irons; we also use air for operating the hammers in the truss rod shop as well as operating the angle and forming presses for making standard forgings in car works. In the shop yard we operate the transfer table of the erecting shops, and run the engines from this shop to the roundhouse with air. For handling cars and for all switching in the shop yards we use a compressed air motor built in Topeka shops. The following list gives some idea of the uses to which we put compressed air:

Whitewash and paint machines.
Drop-pit jacks.
Car jacks.
Coach jacks. .
Jacks in ground to act as turntables.
Wheel hoist, for loading wheels on flat cars.
For operating six-ton swinging cranes.
Bolt shears.
Elevating sand in tower for sanding locomotives.
Distributing oil to the numerous oil furnaces.
Machines for putting couplings and clamps on air hose.
Sand papering machines.
Tin press, for forming tinware.
Blacksmith press for forming angle irons, etc.
For operating transfer tables.
For operating switch engine in shop yard.
Large plate rolls in boiler shop.
Small steam hammers.
Cleaning coaches.
Hoists for machines and lathes.
Saw-tables.
Running locomotives from erecting shop to roundhouse.
Letter presses.
Valve setting machines.
Laboratory engine.
Fans.
Paint burning tools.
Tire setting and removing.
Gasoline machine for heating patches, frames, etc.
Painting freight cars, depots and bridges.

THE USES OF COMPRESSED AIR ABOUT RAILWAY SHOPS.

BY MR. B. HASKELL.

In the summer of 1895 we had in our possession an old locomotive boiler and it was thought that it would make a good air reservoir, so far as capacity was concerned. With the expenditure of a few dollars a new front tube sheet, containing only nine 2-inch tubes, was applied. This reservoir was erected near our boiler room and one 6-inch air pump and one 8-inch air pump comprised our air plant and the nucleus of subsequent improvements. We carried sixty pounds steam pressure in the boilers but we desired eighty pounds of air. To obtain this we used a 11-in. x 33-in. air reservoir between the two pumps, allowing one to discharge into the reservoir and the other pump received air from it. In this way we easily kept up the pressure required until the demand for air was greater than the capacity of the pumps.

We piped the machine shop, roundhouse, car and paint shops, so that air could be used where and when required. We began using air for the purpose of testing our locomotive boilers to maximum pressure, for blowing out steam pipes, steam ports, and cylinders, previous to putting in pistons, and for the purpose of running locomotives from the machine shop to the roundhouse, and vice versa.

The first 8-inch air hoist we made was intended to reduce the cost of loading a car with mounted wheels by the old method, namely; running the wheels 200 feet in order to get them up a pair of skids and onto the car. To load a car with wheels in this manner required the time of six men one and one-half hours, the equivalent of nine hours for one man at a cost of \$1.02. With the use of an air hoist four men can do the work in twenty minutes at a cost of 15 cents, a saving of 87 cents per car load. All heavy castings are quickly loaded, or unloaded, as the case may be, with this air hoist, thus reducing the cost of handling material on and off car fully 50 per cent.

During the fall of 1895 we installed the Leslie fire-kindler; this also required twenty pounds of air to force the fuel oil to the burners; by the use of air and the Leslie fire-kindler we reduced the cost of kindling a fire in a locomotive from 9.54 cents for wood, to 1.27 cents in favor of the kindler operated by air; a saving of 8.27 cents per fire kindled. We next built an air hoist in the car shop for handling coach trucks, and by the aid of this device two men can easily raise the truck frame from the wheels, turn it upside down and place it on horses, made for the purpose, in a few minutes. Previous to the use of the hoist it required ten men to do the same work; the previous method was dangerous as well. We also began using air at that time for testing air brakes on

freight cars and passenger coaches by the use of an engineer's brake valve attached to a portable tripod with the necessary air hose, etc. About this time we began to frost our own deck glass, for passenger equipment, by the use of the sand blast; we are able to frost a deck glass for 12 cents per glass, labor and material, a saving of 60 cents.

Our attention was next attracted to the use of air for dusting coach seats, seat backs, carpets, and the interior of passenger cars. In this we have a great advantage over the old way, as we do not depend on fair weather during which to clean the cushions in the paint shop; the cushions are taken to the third story and there thoroughly dusted. Prior to the use of air for dusting cushions, the cushions were taken outside of the shop and pounded and swept in order to clean them. We also bring the coaches to the shops for the purpose only of dusting them out. One man can remove the cushions and seat backs and thoroughly dust them and also blow all the dust out of the interior of the coach and have the car ready for service in three hours, and do a much better job than is possible by the old way which required ten hours. We use a flat fan nozzle 3 inches wide with an opening $2\frac{3}{4}$ -ins. long and only a full 1-64-in. wide. In this operation we save 87 cents per coach cleaned.

We then found so many uses for compressed air that it became absolutely necessary to provide means for compressing more of it, so an air-compressor was purchased. Soon after the purchase of the compressor we purchased two pneumatic hammers and two air motors. By the use of the pneumatic hammers we have reduced the cost of beading a set of flues from \$2.50, by hand, to 72 cents, by the air device. By the use of the air motors we have reduced the cost of tapping staybolt holes and screwing in staybolts from \$45.90, by hand, to \$15.30 per new firebox. It would also cost \$17.78 per firebox to drill the ends of staybolts; with the air motors it costs \$4.62, a saving of \$13.16. Another advantage gained is the difference in time now required to apply a new firebox and the time required before using compressed air; we can now give an engine a general overhauling, including a new firebox, in less than thirty days. A few years ago it required sixty to seventy days to do the same work. We use compressed air with portable forges for heating rivets. Also for straightening locomotive frames, when bent by accident, without taking them off of engine. We also use air and gas for removing and applying driving-wheel tires. We can remove a set of tires for 50 cents and apply a set for 87½ cents; this does not include labor, but on account of the convenience of the arrangement the cost of labor is reduced materially.

Since the introduction of the paint spraying machine we have reduced the cost of labor for painting cars approximately 92 per cent. We use the same spraying machine for whitewashing at a cost, for labor and material on plain surfaces, of 1 cent per square yard. We have lately whitewashed the interior of our machine shop with the air machine and this would have been a very difficult thing to do with a brush on account of the height of the shop. It has improved the appearance of the shop wonderfully and makes it more light and cheerful for the workmen. We have our freight yard, or cripple tracks, equipped with air. Here we use the spraying machine on freight cars and test

the air brakes on freight and passenger equipment. We also use, on these tracks and to great advantage, air motors for boring holes necessary in the application of air brakes, and for other repairs to cars.

We recently built an air compressor and attached it tandem to our shop engine; this affords us 3,524 cubic feet of free air per minute in addition to what we already had. We now have air hoists over every machine on which heavy work is handled, thus saving the cost of lifting the work by hand and doing it much quicker. We also use a 14-inch air hoist for lowering dirty machinery into and out of a large vat in which we clean all locomotive machinery, including driving-wheels. We have a device for pressing jaws of bottom connections and push rods of air brakes into 1¼-inch pipe and then crimping the pipe to the malleable iron jaws; this, also, is operated by air. We have a number of small air breast-drills which we use for drilling the ends of staybolts, etc.; a man receiving 14 cents an hour drills from twenty-eight to thirty staybolts an hour.

Instead of boring out locomotive tubes with the auger we use an air device for this purpose, with which we can average one flue cleaned per minute. We have a drop-pit for the purpose of removing locomotive driving-wheels without the labor of jacking up the engine. This is a great convenience and time saver; it is also operated by air. We use our pneumatic hammers and motors throughout the roundhouse on running repair work, and this, also, is a great convenience. We have several air cylinders located in the center of tracks and these act as turntables for turning pairs of driving and other wheels mounted on axles. This does away with jacks and other devices formerly used by hand. Several months ago we set up our reservoir (old locomotive boiler) in one corner of blacksmith shop; it stands perpendicular, resting on the boiler head; the firebox portion has been neatly closed with flooring, and door applied in such a way that the firebox provides a neat cupboard in which tools are kept. The nine tubes which acted only as stays are now utilized for passages for the exhausted steam from the shop engine, which is near by, and thus the air in the reservoir is heated and expanded. The condensation in the tubes is taken care of by a Gold drip.

In preparing new locomotive tanks for the priming coat of paint we use the air and sand blast instead of rubbing the tanks by hand; to do this by hand rubbing would require one man about thirty-five hours, or a cost of \$3.50; to do it by sand blast and air requires a man two hours at 14 cents per hour, or 28 cents; one man two hours at 10 cents per hour, 20 cents; a total of 48 cents. The difference in favor of sand blast and air is \$3.02.

We use compressed air in connection with the following appliances:

Locomotive fire-kindler.

Removing and re-setting tires.

Burners for removing paint from coaches.

Portable engine for boring cylinders, etc.

Pneumatic hammers for flue beating, chipping and caulking.

Pneumatic drills.

Pneumatic boring machine.

Portable forges.

Dusting coaches—cushions and carpets.

Air and fuel oil for straightening frames and firebox sheets.

Oil tanks at store room.

At different benches for testing air pumps, triple valves, bell ringers, reducing valves and regulators.

Removing and re-setting tires with fuel oil and air, costs, as compared to cost of handling wheels to outside of shop and heating with wood:

Handling 4 set of tires, 10 hours, 12½ cents per hour.....	\$1.25
Heating 4 " " 20 " 12½ " "	2.50
Two cords wood, 75 cents per cord.....	3.00
	— .75
Heating 4 set of tires with oil and air:	
6 hours labor, 12½ cents per hour.....	\$0.75
20 gals. oil, .021 cents per gal.....	.42
	— \$1.17

Saving on 4 set of tires..... \$5.58

During 1897 we removed and re-set 258 tires which, at above rate, would represent a saving of \$359.91.

AIR PAINTER.

Comparative cost of painting a 34-foot box car with air painter, two coats, and the same by hand. This statement shows a saving of 67 cents per car, or \$134.00 per year for the same number of box cars repainted in 1897:

Labor, 40 minutes, 12½ cents.....	\$0.08
Lettering, 3 hours, 12½ " .....	.37½
5 gals. paint, 60 "	3.00
2 lbs. white lead, 6 " .....	.12
	— \$3.57

Painting a 34-foot box car by hand:

Labor, 6 hours, 12½ cents.....	\$0.75
Lettering, 3 hours, 12½ " .....	.37½
5 gals. paint, 60 "	3.00
2 lbs. white lead, 6 " .....	.12
	— \$4.24

Cost of air painter, \$46.83.

Burning paint off of coaches: As near as I can estimate, the saving is 50 per cent. over cost of burning off with hand burners.

Cost of burning off one coach with hand burner:

60 hours, 23½ cents\$14.10

Cost of burning off one coach with air burner:

30 hours, 23½ cents \$7.05

Saving on one coach, \$7.05

Saving per year (22 cars 1897),\$155.10

A portable engine in machine shop is run by air. We use this engine to bore out cylinders and plane off valve seats. I estimate that it makes a saving of at least 10 per cent. We have the drilling machines fitted with air to blow out chips when drilling deep holes. This saves stopping the machine to brush away the chips.

Pneumatic hammers for tube-beating, chipping and crulking: With the new hammer it costs 25 cents to caulk 100 flues, and by hand the same work costs \$1.05—a saving of 80 cents on each 100 tubes; in 1897 we re-set 7,736 tubes, saving for the year \$61.89; although in 1897 we were using the old hammer and the saving was 10 cents per hundred less, as previously shown.

Saving in tapping out staybolt holes: One man at 15 cents per hour will tap out, by hand, from seventy-five to eighty staybolt holes in ten hours, and with the machine 175 to 200 staybolts. One man at 15 cents per hour will put in, by hand, from 175 to 200 staybolts in ten hours, and with the air machine from 300 to 400 in ten hours.

Pneumatic boring machine: We have recently got this and, so far, have used it in connection with air brake work only, and will continue to use it on this work. By its use we are able to do away with two men, thus saving \$2.52 on every four cars, and by December 31, 1898 we expect to have equipped 500 cars; a saving of \$315.00. I think that this wood-boring machine would not save as much, comparatively, on miscellaneous work as on air brake work, because of the time used in setting up the machine. We have connections so that we can use air on portable forges on cripple-track and about the shops, and I estimate that on account of the convenience there is a saving of 20 per cent.

Dusting out coaches and cleaning cushions and carpets: We are using air for this purpose at Grand Rapids, and foreman Canan has made a test several times and finds that one man can thoroughly clean cushions and backs and from behind steam pipes and window curtains in three-fourths hour per car, while it takes four men about the same time to go over a car in the old way and then the car is not cleaned as satisfactorily as with the air appliance. He further states that if there were a greater pressure there would be still greater saving, as now they have to wait at intervals to let the pumps increase the pressure. The saving is about 25 cents per car in labor. Cleaning by air results, of course, in much less wear on cushion covers, etc.

We use air and fuel oil for straightening up frames and sheets in fireboxes and consider it safe to estimate the saving from 10 to 15 per cent. The oil tanks at the store room are equipped with air pressure and there is probably a saving of 25 to 50 per cent. in labor over pumping the oil by hand.

THE CHAIRMAN: None of these gentlemen is present, unfortunately. The Secretary will briefly present some additional information which was received just previous to the opening of the meeting.

THE SECRETARY: There are four uses, in addition to those enumerated in the papers, to which compressed air has been applied by the Atchison, Topeka & Santa Fe. Files are cleaned and sharpened or recut, by the action of a sand blast, and the cleaning is much quicker done than by any other means and the usefulness of the files is prolonged. Journal brasses are cleaned before re-lining and this is done with the same equipment as is used to clean and sharpen files. Locomotive tanks are cleaned preparatory to painting and this operation is more rapid and gives better results than hand work. The fourth is the application of a coating of sand to the ends of baggage, express and other cars; the coating to protect the ends from the injuring action of cinders from the stack. The first two operations are probably the more novel.

MR. J. N. BARR (C., M. & St. P. Ry.): The Secretary spoke of the application of compressed air to the cutting of files. I am rather inclined to think that this new use of compressed air is possibly so old that people have forgotten it; it is pretty nearly so old that I had forgotten it, but I know that twenty-five years ago, the use of compressed air and sand for re-cutting files was in vogue and was supposed to be very successful. That is like some jokes; they get so old that they become new and are enjoyed heartily. I am inclined to think that this ought hardly to be classed to-day as an addition to the various uses to which compressed air can be put.

I believe in the use of compressed air in its proper place, and the papers that we have presented here give quite a number of uses to which it may undoubtedly be put with advantage. Since we have started to present additional uses, I want to call your attention to two. I saw an illustration in one of our technical papers, and I presume others have seen the same thing; it was the application of compressed air to putting baggage in baggage cars. Each baggage car is equipped with an air hoist operated by air from the air brake system. I suppose that the trunks are brought up and set on the lift; there may be a hook, I do not know how that part of it is handled, and the trunk is raised up and swung into the car. That is one additional use that I have discovered lately. There is also another

one which I saw illustrated in one of our papers; a compressed air hoist for handling the steam chest and steam chest covers of locomotives. The compressed air apparatus is bolted to the smoke stack. I tried to figure out about what was the relative weight of the compressed air apparatus bolted upon the smoke stack and what was the weight of the steam chest that it would have to lift off, and I am inclined to think that it would take about twice as much labor to put the compressed air apparatus up there and get it attached to the smoke stack as it would to take hold of the steam chest and lift it off by hand.

Those two things are fair illustrations of what we are doing, if I may say, with the fad of compressed air. I am afraid that we are riding a hobby to death, and while the use of compressed air is all right in some places, I think that the old horse has been ridden pretty nearly as far as he can go.

MR. P. H. PECK (C. & W. I. R. R.): We use compressed air in a great many ways in our roundhouse but we are not to the point yet of opening roundhouse doors with it.

MR. J. F. DEEMS (C. B. & Q. Ry.): About two years ago, I think, there was a paper on this subject, read before the Club, and at that time I rather took the position that Mr. Barr has taken; that I thought compressed air was used in a good many places where it was really not economical, and in reading these papers over this morning I could not help thinking of the story of the hod carrier who was elated over the fact that he had nothing to do; he just carried the hod full of bricks and mortar to the top of the building and the man up there did all the work. Some of the statements about compressed air would lead one to think that all the man had to do was to turn on the air and then he could go off and enjoy life and let the air do the work.

I recall an instance which happened not long ago, when I was going around the shop with a friend; we were looking at a small machine for drilling test holes in staybolts; the boy was feeding the drill with a lever attachment, and the friend suggested the idea that air pressure be used to feed the drill and thus the boy would have nothing to do while the feeding was going on. It seems to me that in some instances the use of compressed air is in similar ways to this carried to what seems to me ridiculous extremes. I notice that in one of the papers mention is made of blowing chips out of the

holes in course of drilling, by using compressed air; I believe that it will be found if compressed air is available in the drill press room for such purpose, that it will be used as a fan in the summer to cool the workmen, quite as often as to blow out the chips, and whether or not this would be advantageous and proper, might be questioned.

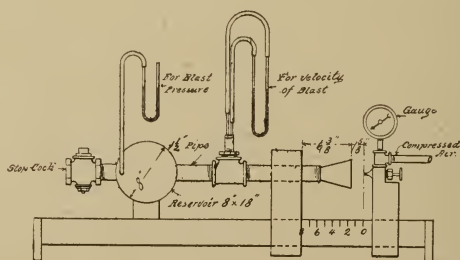
I notice another thing in the papers; mention is made of the use of compressed air for loading mounted car wheels. I think that if a depressed track is arranged, where it is possible, so that the tops of the cars can be dropped down on a level with the surface tracks and the wheels can be rolled right on to the car and then put the men to loading wheels at so much per pair, it will be found that compressed air will not be used very extensively for such purpose. I think that the men will prefer to roll the wheels on to the cars on a level. Four or five cars may be connected with rails extending over them, making a continuous track. I realize, however, that local conditions may be such that the depressed track cannot be provided, and in such case the compressed air doubtless would be, or at least it might be, advantageous.

There is another point in connection with the use of compressed air which, it seems to me, has not received the attention that it should; that is the question of using some kind of a flexible pipe in the place of so much hose. The hose is dragged around the floor and it gets covered with oil and deteriorates very rapidly. The hose is a much larger item of expense than many realize, and, I think, is something that should receive attention. At a shop where I was visiting not long ago, my attention was attracted to the air plant; there was a very nice one, a very fine compressor, but for some reason it was not located conveniently to the cheap fuel used in the boilers of the main power plant, but was located where it was necessary to use a good lump coal, and it occurred to me that it should have been located conveniently for the use of the cheaper fuel.

During the past month I visited two manufacturing establishments in the east, both of which are up-to-date, and, to my surprise, I found them using hand-operated ratchets and drilling by hand in many of the shops. I could not quite understand it. We railroad men are accustomed to having the manufacturing establishments held up to us as examples, and I wondered whether we were making a mistake in using air motors for drilling. Those manufacturers are not using air, but I think that we are not making a mis-

take, because I think if there is any one place where compressed air can be used to advantage it is in drilling. I cannot understand why these manufacturing establishments are not using air motors for this purpose.

In a previous paper read before this Club, the statement was made that compressed air could be used to advantage for a blast, and about a year ago I was talking to a gentleman from the east who was introducing the use of compressed air for this purpose. He uses a very small air jet in connection with a funnel-shaped opening and leads the induced blast thence to forges and he thought he was getting very good results. However, he did not claim that the arrangement was equal to a fan. In order to get some figures on this point, I had some tests made, the results of which were given to me yesterday evening. I have not had time to look them over very carefully myself, but feel sure that they are fairly accurate. It was found that the very best results obtained in this way were as one to about twenty-five, when compared with a fan. It would appear from this that there is not very much economy in using compressed air, except in places where there could not be utilized the blast from a fan. This would be an excuse, sometimes, for the use of compressed air. The figures are rather startling to me. I did not think there would be as much difference as is shown. The apparatus with which the tests were made are shown in the illustration with this, and the results are given in the annexed tables.



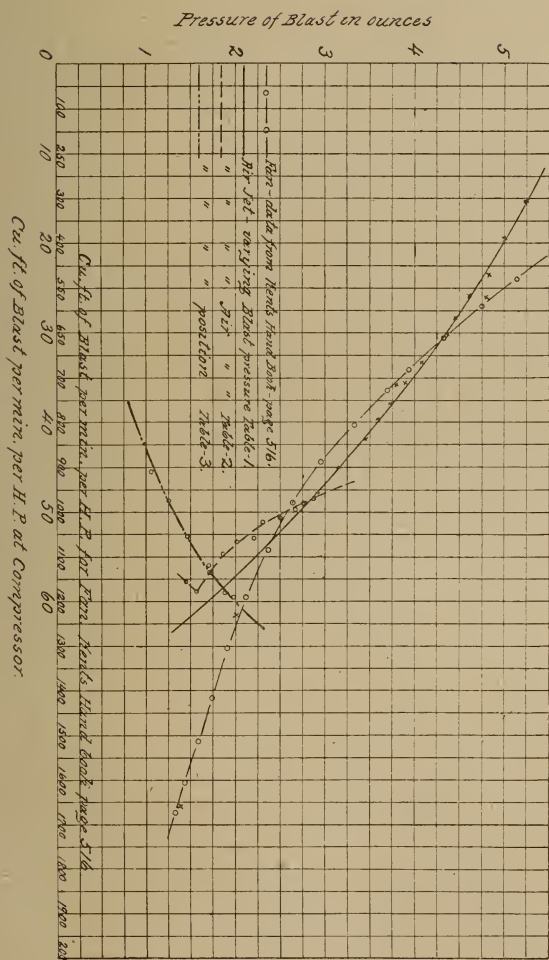


Table No. 1.

Observation Number	Pressure of Blast in ounces	Vol. of Blast in cu. ft. per sec.	Cu. ft. of Blast, per cu. ft. of compres'd air used	Cu. ft. of Blast, per min. per H. P. at compr'sor	REMARKS.
1	1.85	1.977	6.531	58.779	Air pressure constant—(100 lbs). Position constant—(No. 8). Blast throttled with 1½-in. stop-cock. Ob. 1—B ast pipe free, stop cock off. " 2—stop cock on pipe, wide open.
2	2.90	1.607	5.310	47.790	
3	3.15	1.517	5.012	45.108	
4	3.45	1.410	4.657	41.913	
5	3.60	1.337	4.418	39.762	
6	3.725	1.274	4.209	37.881	
7	3.90	1.200	3.965	35.685	
8	4.075	1.122	3.706	33.354	
9	4.35	1.021	3.374	30.366	
10	4.45	.954	3.153	28.377	
11	4.625	.8731	2.883	25.947	
12	4.825	.793	2.620	23.580	
13	5.00	.643	2.175	19.575	
14	5.25	.514	1.700	15.300	

Table No. 2.

Observation Number	Air Pressure Gauge	Pressure of Blast, in ounces	Vol. of Blast, in cu. ft. per sec.	Cu. ft. of Blast per cu. ft. of compres'd air	Cu. ft of Blast per min. per H. P. at compr'sor	REMARKS
1	100	2.85	1.628	5.378	48.402	Constant position—(No. 8). " opening in blast pipe; stop-cock wide open
2	95	2.75	1.597	5.475	49.275	
3	90	2.65	1.555	5.549	49.941	
4	85	2.50	1.512	5.634	50.706	
5	80	2.30	1.456	5.691	51.219	
6	75	2.20	1.427	5.900	53.100	
7	70	2.00	1.356	5.925	53.325	
8	65	1.85	1.300	6.072	54.648	
9	60	1.70	1.248	6.296	56.664	
10	55	1.55	1.221	6.543	58.887	
11	50	1.45	1.165	6.442	57.978	

Table No. 3.

Observation Number	Distance from jet	Pressure of Blast in ounces	Vol. of Blast in cu. ft. per sec.	Cu. ft. of Blast per cu. ft. of compres'd air used	Cu. ft. of Blast per min. per H. P. at compr'sor	REMARKS
1	7	1.975	2.002	6.614	59.526	Air pressure constant—(100 lbs). Blast outlet constant—stop-cock taken off.
2	8	1.875	1.986	6.559	59.031	
3	9	1.700	1.892	6.248	56.232	
4	10	1.475	1.774	5.860	52.740	
5	11	1.250	1.648	5.444	48.996	
6	12	1.050	1.530	5.053	45.477	

Table No. 4.

Compressed air used by "jet" at various pressures.

Air Pressure.....	100	95	90	85	80	75	70	65	60	55	50
Cu. ft. of compressed air per sec.....	.3027	.2917	.2803	.2684	.2559	.2419	.2288	.2141	.1982	.1866	.1809

I cannot but smile about what Mr. Barr said about lifting the steam chest with an air hoist. I had an experience of that kind, and with quite a number of air tools, which the introduction of piece work consigned very quickly to the scrap pile.

MR. BARR: We have been using compressed air somewhat. I do not want you to understand that we have never used it at all; we have used it and we are using it now; we have a little corner at the locomotive shops where we can not get in a depressed track, as Mr. Deems suggests, but where we have to put a great many wheels, mounted on axles, on to flat cars. There we have a little air hoist, and it does the work very well. I do not know that we could put anything there that would do the work better, under the circumstances by which we are surrounded, than does the air hoist.

As to cleaning coaches with compressed air, I started in with a great deal of hope that we were going to reduce our expenses for this work at Western Avenue, which is our largest cleaning yard in Chicago, and put in a blower; I think that I got one of the most approved, specially designed nozzles. I went there one day and asked the men how they were getting along. They said, not very well. "Now," I said, "look here; there are a great many roads cleaning cars with air and if they all find advantage in it, it seems very curious to me that you can not find that there is some good in it." They said it was not very good. I asked them why it was not, but they could not make it very plain, so I went down to the yards to learn. They started in to clean a car with air and they did it thoroughly; they made the dust fly and I had to get out; but they got that floor cleaned and the car looked very nice. "Now," I said, "what is the matter with that; that is good; you can not clean it in that time in the old way." "No," they said, "not quite, but we are not done; it will take about as much time to wipe that fine dust out of these berth fronts and other places and complete the cleaning as it does to sweep the car and clean it afterwards." That fine dust that was stirred up by the air blast covered the berth fronts and lamps and all parts of the car and it was very hard to clean it off, and I am satisfied that the men used a great deal more time in removing that fine dust than would have been necessary had they swept the car in the ordinary way. I would like to hear the experience of some other members on the other side of the question.

MR. C. L. SULLIVAN (Cloud Steel Truck Co.): I cannot make

any remarks bearing on the point which Mr. Barr made last, not having had any experience in cleaning cars; but I can say a word on the cost of doing work with air motors. Referring to the tables given by Mr. Haskell, the total saving given for removing and resetting tires is \$5.58. If there were added, as I always do in such estimates, the interest on the investment of the machine and the cost of repairs to the machine, that is, some percentage of the original cost of investment, and for repairs, running into general expense and profit and loss, I think the difference would disappear entirely in that particular case; and I think it would in many other cases. If we take any particular job on which we are substituting air machines for manual labor, we should put in with the cost of the air machine these items of interest on the investment of the machine and some percentage for cost of maintenance, and if this is done the difference would not show so great in favor of the machine. In many cases on which I have figured, the difference would be on the other side. Now in the case of a man, we have no particular interest in him in the way of investment, or in profit and loss, but we have in the machine. We buy it and we must keep it in repair, and I never in my estimates in shop work, omit to put in these items. I think the same rule applies in the table on painting. There is nothing in the table, so far as I can see, covering these particular items. I think it would be interesting if we should take these headings in the paper by Mr. Squire and which give the different uses to which the air machines are applied, and figure them out on the line that I have suggested, I think we would very often find that in many of them it is unprofitable to use air.

MR. M. H. WICKHORST (C., B. & Q. R. R.): At Aurora we have a painting machine which is used for painting freight cars. Some time ago the matter was turned over to me to find out what the actual cost would be of painting cars with it. I made tests with three cars at three different times; the tests consisted of finding the time required to paint by the brush and also with the air machine, noting also the amount of paint used. It was shown that although it required a very much shorter time to paint with the spraying machine than with the brush, the painting machine used almost twice as much paint; that is, the spraying machine will spray considerable paint in the air which the wind will carry away. If there is not much wind the paint will strike the car, but if there is wind, the

paint will be carried away by it. The conclusion was there was not much difference in the cost in the two methods. I make that argument as a comment on figures given in Mr. Haskell's paper where it is assumed that the same amount of paint will be used in either case. In concluding my report I stated that if it should be decided to use a spraying machine, it would be necessary to have some method of checking the amount of paint used, because a man could readily operate a machine in such a manner as to waste considerable paint.

MR. JOHN MACKENZIE (N. Y. C. & St. L. R. R.): One thing was brought to my mind by what Mr. Barr said; that there are a great many things which might be done by air, one of which I heard of when I was east. A man had a small air motor operating a turntable, and in talking about it with some one from the traffic department of the road, he said that the motor was not only turning every one of their engines, but quite a number of engines for other roads, also; it was so industrious that it was turning the business of the competing roads over their line. So you will see there was one place where air was doing good work for one road.

MR. MORSE (Grand Trunk Ry.): I would like to ask whether it is found, in comparing air motors with manual labor, that anything is gained in facilitating the work? It seems to me that a man can do much more work with the air motor than he can if he has to run taps by hand, especially where there is a large number of holes to be tapped, as in stay bolt work. Much will depend upon the amount of the same class of work to be done at one time.

MR. DEEMS: I notice in the paper by Mr. Squire, in the table giving the uses to which air is put, is mentioned "car jacks;" I can cite two instances in which these car jacks were in use in freight car yards, and from which they disappeared immediately when the men began to make repairs by piece work; it took too long to lug around the heavy jacks to the places where they were wanted. In the table is given, also, "Fans;" that is all that is said. Are we to understand that they use an individual motor to run a fan? Is there anyone here who can make this point clear? Or is the compressed air used in the form of a jet to produce a blast? It seems to me that in either case, unless there are some special conditions to make such use necessary, it would be unprofitable.

MR. H. M. PFLAGER (Pullman Company): The Pullman Company uses air quite extensively for cleaning cars, because cleaning

by air is more effective than is the old method of cleaning. The cost for labor in cleaning by air is reduced, but this reduction is offset by the cost of the air, which, at most cleaning points we purchase from the railway companies.

THE CHAIRMAN: I would say that in cleaning passenger cars with air, much of the dust is gotten out of the car that cannot be gotten out with a broom; the air penetrates through the blinds and crevices and such places which cannot be reached otherwise. We have had excellent results in cleaning our passenger cars. As Mr. Barr says, it is not a great saving of expense, but we think we get our cars much sweeter and cleaner in doing the cleaning with air. We do most of our painting of freight cars with air, and we certainly save money in doing it. I have a statement before me which shows a saving of over 30 per cent. in using air in place of hand painting.

Mr. Sullivan has covered a point which is very essential, about the cost of maintaining the air plant; that is not always taken into consideration in figuring the cost of compressing air; it costs something to maintain the plant. We are running our elevators, many of our drills, doing all our boring of draft timbers, putting up our air brake work and, in fact, doing everything on the repair track with the aid of air that can be done. The machine shops are thoroughly equipped with air and many of the machines are run with air motors.

One gentleman spoke about depressed tracks. Before I came west our superintendent was going to put in a crane to operate which required six men. We put in a depressed track and two men could load and unload all the wheels. I think a depressed track is the best thing for loading and unloading wheels. Mr. Barr, if I remember his remarks, stated two years ago that it took longer to rig up the steam chest hoist, put the chest on and put the thing in place than it did to perform the work by hand; I agree, in that case, with Mr. Barr. There are different cases which I had hoped some one would mention.

In regard to passenger car cleaning, we certainly feel that we are cleaning better by using compressed air. The Pullman company is buying air of us with which to do its cleaning in Chicago. We buy air of the Terminal people at St. Louis with which to do our passenger car cleaning, and so far we have had satisfaction.

In making up our statements of the cost of painting by hand and

by sprayer, I have watched the matter very carefully, because if I make a statement I want it to be correct. I have seen the paint weighed, measured and tried in every way and I know that the statement showing that we use less paint with the air machine is correct; that is, when we are painting in shops and, therefore, are under cover.

MR. MORSE: The subject of depressed tracks is rather a tender one with me, inasmuch as we had quite a good many of them for loading wheels, and also taking care of cinders, and by my request they have been filled up. We could only use them six months out of the year without spending a great deal of labor keeping the snow and ice shoveled out, and we have substituted air hoists to quite a considerable extent. We load material, wherever we can, with a hoist. Our cinders are handled entirely with air hoists and from the time they are removed from the locomotive pan until they are put on the track for ballast, it is not necessary to touch them with a shovel. We rake the cinders into a basket, the basket is hoisted, dumped into the dump car and taken out on the road and there dumped alongside the track. We thought that in doing away with the depressed tracks, we accomplished quite a deal of good. In regard to turntables, when we started to run our heaviest power on the divisions where we have light turntables, it took the entire shop force to handle the table, whereas by providing the tables with air motors, we can turn them with one hand.

MR. THOMAS PAXTON (A., T. & S. F. Ry.): The cleaning of coaches with compressed air probably produces no great economy, but I think it is true that better results will be obtained by using compressed air. At our 18th Street shops we have used it and I have watched the method of handling the work. Seats and backs may be pounded indefinitely with an ordinary rattan seat beater, and it will not be possible to get all the dust out of the plush; whereas the current of air under pressure from the nozzle will knock the dust right through the plush and keep the seats clean. It will also penetrate the cracks and corners of the car, and, as you say, give a cleaner car, though perhaps at not much reduction in expense.

The disposition to attach tandem cylinders to shop engines is perhaps open to question. The nature of the work done by the shop engine requires that it carry its varying load under a constant speed, while the exact reverse of this is expected of an air compressor; the compressor should maintain a fixed pressure or load, regardless of

speed. It is no doubt a fact that a great many master mechanics have been, by sheer force of necessity, compelled to use tandem compressors on shop engines, but good practice, I think, dictates that such machines shall give place to the regulation compressor wherever it is possible. At the Fort Madison shops of the Santa Fe road, in addition to many of the uses enumerated in the papers before the club, we use compressed air for operating heavy boiler shop clamps, for punching off old car roofs, for preparing decorated glass for coach use, cleaning paint from locomotive tanks, those of course receiving general repairs, and cleaning car brasses that are brought in to be re-babbeted, also cleaning and re-sharpening files that have been dulled. The sand blast as a means of removing paint from tanks undergoing heavy repairs does very efficient work. I have cleaned a number of four-thousand-gallon tanks complete at a cost of 80 cents each. Where the sheets are pitted, I know of no means of getting the rust out of the pits equal to the sand blast; I think it will be difficult to find a process that is any better.

With reference to Mr. Barr's remark that the sand blast for sharpening files is an old thing; that is quite true, it is even older, doubtless, than Mr. Barr says it is, but in its use as applied to cleaning and so lengthening the life of files as ordinarily used in railroad shops, I think investigation will show some economy to result from such use.

MR. BARR: I think that Mr. Paxton's remarks are very just and very sensible. I agree with both speakers on the subject that the dirt can be removed from the car better with air than otherwise, but that is not the question presented in these papers; I was discussing the paper in which is shown such a decided economy and I think that the economy is scarcely discernible. Mr. Paxton rather agrees with me on that, and I believe that he has had a great deal more experience in it than I have had. There is not much saving in money in cleaning cars with air, but I will admit my belief that better work is done with air, and that is quite an important consideration. I think that on those grounds we can agree on the question of car cleaning.

I have made some of these remarks in order to bring out discussion, and I would like to hear a little more discussion of the subject. I believe that this Club, in talking over the matter freely, will come to a pretty fair and sensible idea on the subject of the use of com-

pressed air. We are using air in our upholstery shops, or outside of our upholstery shops, cleaning all our cushions and carpets with it, and can not do it as well in any other way. What I deprecate, however, is that a railway mechanical organization should place itself in the position of endorsing some of the fool devices to which this very useful medium is put, and I think we ought not to so place ourselves.

MR. SPENCER OTIS (Omaha, Neb.): A few days ago I learned of an application of compressed air to an operation, which application was entirely new to me. Iron which is to be welded but which, after scarfing is somewhat below the welding temperature, may be raised to the welding temperature by turning onto it a jet of air. It requires a very few moments to bring the iron to the proper temperature and the cost is much less than is the case when the iron is returned to the forge for re-heating.

MR. PAXTON: We have given much thought to the question of painting cars by compressed air. We have carefully weighed the paint and adopted measures to determine which was the most economical, to paint by hand or by compressed air, and we are of the opinion that we can best paint with the sprayer, much better than we can with the brush. We do a better job and immensely more of it than by hand. There are all sorts of paint sprayers in the country, from the juice slinger that throws out intermittent slugs of paint and air, to the perfect atomizing machine; if you get the latter you are sure of good results.

MR. DELANO: I would like to ask some questions concerning the transmission of compressed air. Can any of the gentlemen present tell us what is the best method of conducting it; whether underground or overhead? I have had some experience with the use of air in signaling plants, and in such plants it is usual to carry it in pipes laid below but close to the surface of the ground, but it has been found that it is sometimes very expensive, especially in the winter, to locate a leak and repair it.

There is another question that I would like to ask. Do the users of compressed air determine the amount of air they are compressing, and the amount of air they are actually using with their air tools and thus ascertain the amount they lose in leakage? In my experience in running signal plants I have noticed that a compressor keeps on running at about a certain speed whether it is Sunday or whether it

is a week day, whether the switches or signals are moved frequently, or whether they are moved infrequently, and that has always seemed to me to point to the fact that about one-half of the air, or perhaps even a larger proportion, being compressed was leaking out. In fact, about the only time we could detect small leaks was when the ground was wet in the spring, for then we could see the water bubbling over the pipe. It seems to me that that is one of the difficult things in the use of air or electricity, and many another good thing; leakage goes on, and it takes very careful experiments and very scientific, painstaking work to find out where the leak is. If some of the members can throw light on both of those questions, I would be much obliged.

MR. C. J. CLIFFORD (C., L. S. & E. Ry.): I have heard the report from our Chairman, of saving about 30 per cent. in painting cars with paint machine; our company has carefully weighed the paint used, and time employed in painting with a machine, and have saved over 30 per cent. The gentleman who made a trial on three cars, and said it was no saving over the hand method on account of waste of paint when not painting, must have neglected to stop the air pressure, and allowed the paint to run to waste. The report of this Club on painting with air pressure machines, no doubt, will be read with interest by members of the Painters' Union, and, judging from my own experience, I think they are opposed to its use. I have every reason to believe it will facilitate our work, and not be any detriment to the painting fraternity.

MR. WICKHORST: I said there was a waste, and it is true that if there is a wind blowing some of the paint will not strike the car. Of course if the work is done indoors the waste can be avoided. As a matter of fact, although the men can have the use of the paint machine, they do not use it very much. They have a choice of two different painting machines.

MR. DEEMS: Is the painting of cars done by the day or by the piece?

MR. WICKHORST: It is done by piece work.

THE CHAIRMAN: Ours is all day work.

MR. E. W. PRATT (C. & N.-W. Ry.): In reference to Mr. Delano's inquiry in regard to the pipe transmission of air, I would like to say that when the necessity for protecting the pipes is not as great as it would be for a signal plant, where, perhaps, in case of

strikes, railway disturbances or derailment of cars, pipes laid near the surface would be injured or torn up, there is no reason why any moisture should be carried through a long pipe system if the water is carefully extracted before entering the pipes, and the repairs are much more easily made than with pipes buried deep. The expense of laying is much less if they are laid on the surface, where possible, or very near the surface. At many of our test plants for cars the pipes are laid on, or near, the surface. If there be sand, gravel or cinders as ballast in these places, burying the pipes sufficiently so that a wheel, a drawbar, or anything falling upon them will not injure them, it is best to lay them in that way, better than to bury them, box them in, and go to the expense of trapping them and protecting them. I think that there would be no trouble if that were the only objection in the matter, that is, from the moisture; if the air be conducted through many coils of pipe (similar to a condenser) and thus cooled and all the water trapped out before the air is admitted to the mains.

THE SECRETARY: Mr. Barr did not quite get the baggage loading apparatus completed; there was a weighing apparatus on it; and it was supposed that the collections for excess baggage found by the apparatus and which, probably, would not be found, were it necessary for the baggageman to take the baggage to the scales, more than paid for the apparatus and the compressed air required for its operation. I believe that the apparatus is in use in Michigan.

MR. BARR: We weigh all baggage offered to us to determine the excess weight, and we get quite a revenue from it, but I did not know that it was necessary to have compressed air on the baggage car for a hoist in order to use the scales.

On motion of Mr. Mackenzie the discussion on the paper was declared closed.

TOPICAL DISCUSSION.

THE CHAIRMAN: One of the subjects for topical discussion is: "Is it Not Desirable that a Better Design for Flat Car should be used, and one less liable to be broken in two in Train Movement and in Switching?" We have a blue print here of a flat car; also a communication from Mr. William Smith, transmitting the print.

The Secretary then read the following letter:

F. M. WHYTE, Secretary, 225 Dearborn St., Chicago.

Dear Sir: Referring to your circular of February 7, I send you a design of flat cars used here. I do not know that there is anything very new about it. We counter truss the cars that we have been building recently, and I think that the counter trussing saves a good many of them from being doubled up when not loaded.

Yours truly,

WM. SMITH,
Supt. M. P. & C.

MR. DELANO: I believe that I was the guilty party who suggested this subject, and at the time I suggested it, now nearly two months ago, I was looking at this question from the switchman's standpoint. I had found that quite a number of cars had been broken during the year, both our own and foreign cars, in switching. I also learned of cars broken on the road in stopping trains. On our road, and I presume on most roads, there is a rule that an empty flat car shall not be put near the head end of a train, but to place them near the rear of the train. In looking into the construction of flat cars, it seems to me that it has not improved in recent years. Formerly it was common, in the days of 28-foot flat cars, to build them with 12-inch sills, and to hang them low, with drawbars between the sills, so that the buffing blows would be received in the line of greatest strength. There was very little attention paid to the truss rods; some cars were built without any truss rods, and the trussing was very shallow when used. Now we build a car thirty-four or thirty-five feet long (some in general use on the Northern Pacific are forty-two feet long) and we depend almost entirely on the truss rods; a car is built with 9-inch sills in place of 12-inch sills as formerly, and the sills are placed above the line of drawbar and draft rigging so that when the car is empty a tendency to break it *up* is quite marked. I see that some of our neighbors are putting in counter truss rods and it has occurred to me that this was a good move; I am not sure that

counter truss rods or stiffer sills would not make a good improvement in all types of cars. Of course we do not see box cars breaking up, but in watching cars being switched I have often seen box cars buckle or spring upward five or six inches. Now what must take place in the framing of the car, and the roof, when a car springs up that amount can better be imagined than described. It may be argued that when we come to trussing sills down and trussing them up, we might better have done with it and put in iron center sills. I am not sure but that is a correct conclusion and I should be glad to hear from some of the other members concerning it.

MR. F. H. STARK (C., L. & W. Ry.): Is it not a fact that most of our flat car equipment has truss rods of very little angle, and therefore not much leverage? Another feature that I have noticed is that very few of our cars fitted with counter truss rods receive very much attention, and these rods are simply so much dead load carried around without performing any function. I am interested just now in this flat car question, or, in other words, very long, low side gondolas. There is a demand just at this time by a certain company for a 64-foot, low side gondola, and the question of the counter truss has been considered. One of the members of this Club suggested that the counter truss was not necessary on account of having a 2-foot side-board, while others thought that counter truss rods would be necessary. There is one point on which I would like a little information, and that is whether any of the roads represented here have a limit for the length of freight cars allowed to pass over their line. I understand there are one or two roads that place the limit at fifty feet, while the cars that are under consideration and which, probably, will be built, will be sixty-six feet long; I would like to have a little information as to whether such cars would be rejected if offered to any of the western lines.

MR. BARR: Mr. Chairman, I was on the committee appointed to confer with the freight associations and to endeavor to come to a standard size of car. I think most of the railroads are beginning to realize that these long cars are bad things, not only from the constructive point of view, but from every other point of view, and I am inclined to think that a few of those cars will induce a number of the western railroads to take discriminating action against them. The difficulty with cars of that kind is, that it means, almost, that they must be hauled one way empty. The owner of the car might

make a little money by paying mileage on one car, whereas he ought to pay mileage on two, but the two cars will run over the road much better than the one car, be less liable to accident, and would pay the railroads a mileage of 10-8 of a cent per mile instead of 5-8 of a cent. It is a very important consideration, I am inclined to think, for the operating and traffic departments of the roads to consider, aside from the matter of liability to damage, and inadaptability to ordinary service. I believe that such cars would raise a very decided question of that kind.

MR. STARK: In answer to one point raised by Mr. Barr, it is not the intent of the parties to confine the loading of these cars to one way only, but instructions will be stencilled on the side of the cars to the effect that when loaded with short material the load must be equally distributed between the first cross tie timbers and the ends of the car, and the cars may be loaded to the maximum load over the marked capacity.

MR. DELANO: We are getting away, a little, from the subject, but I do want to point out one thing in relation to excessively long cars—that it is not possible to allow the same limit of width on the long car that is allowed on the short car. We have found a great deal of trouble with big furniture cars.

MR. BARR: With reference to the question that Mr. Delano brought up, I am inclined to think that the expense of putting in this extra framing would be more than the advantages resulting from its use, even supposing that with this counter trussing the destruction of the cars on account of doubling up would be entirely prevented. I believe that I am safe in saying that not more than 1 per cent. of the flat cars fail in this way in a year, or possibly a great deal less than that. Now, I do not know what this extra trussing would mean; I do not know how much it would cost, but I believe that that extra trussing on a car would cost at least one-half as much as a set of new sills, and if that is the case, and we did not have over 1 per cent. expense, then providing a remedy for an occasional collapse of this kind would cost much more than the benefit to be derived from it, and it seems to me that this is the way we should figure in determining the question.

THE CHAIRMAN: I have known of cases where flat cars have been struck and broken in two, and the other cars of the train piled upon them. We called them "pipe-stem" cars; they could not be

run against a bumping post without being broken in two. We designed a car with 9-inch center sills and 12-inch side sills and four truss rods; they gave better results.

Is there any further discussion on this subject? If not, we will pass to the next:

“Is it Advisable to Use Water to Cool Hot Bearings on Cars and Locomotives?”

I would like to hear from Mr. Conger, associate editor of *Locomotive Engineering*.

MR. C. B. CONGER (*Locomotive Engineering*): In regard to using water on hot bearings, Mr. Chairman; the Traveling Engineers' Association had that question up at their meeting in Buffalo last September; it was pretty thoroughly discussed but they did not come to any satisfactory decision in the matter so the subject was continued over for this year. Some of the members used water always on hot bearings with no bad effects. Others held the opinion that it should be used only in an emergency, in order to get the hot bearing in condition to take its load through to some place where the engine or car could be set out. Others insisted that the danger of spoiling, or breaking the journal was so great that it was not safe to use water for cooling.

Most of the operative men, like traveling engineers, agreed that rather than delay a train it would be best to use a little water on a hot journal, letting it trickle down on the bearing as the train ran along and oil afterward. Some of them recommended a little valve oil from the locomotive. As far as my observation goes, there is no objection to using water on hot bearings, having never seen any danger from it; many journals would have been ruined if run without being cooled off. When a hot journal breaks off on account of sudden cooling with cold water, very likely it would not have run much farther any way. My experience has been that water is a good thing to use on a hot journal if you expect to take the car or locomotive any farther.

MR. J. A. GRAHAM (C., L. & W. Ry.): I would like to ask if anyone here has had experience with a journal breaking off after heating and cooling with water. The question of using water on a hot journal is one that has been discussed quite considerably, but I have never heard anyone say that they attributed such a broken journal to the fact that water had been used to cool it when hot, or

that the journal on which water was used had given any trouble afterwards. In my experience I have seen water used quite often and on journals that were very hot, and I have not, so far, known of any bad results from it.

MR. BARR: This matter of using water on hot journals is rather an obscure subject; it is one of those subjects that you can talk on all afternoon and possibly then not say very much. With reference to the question raised by Mr. Graham, I will say that we have had several cases of broken journals on passenger coaches, and at least two of those cases were traced up to where they had, a day or two previous, a very hot journal. The matter seemed to me so important, in view of the developments, that we issued instructions that, in case of passenger cars, if a journal became so hot that water had to be used on it, it should be removed from the car on the first opportunity, and then if an examination showed that it was all right, it might be used in freight service, but it should be taken permanently out of the passenger service. I really believe we were on the right track in that matter. We all know that when iron reaches a blue heat, it is extremely weak and brittle; a crack may be formed at that time, and it may be that the use of the water has nothing to do with the subsequent breaking of the journal. Our instructions do not cover the use of water; they simply cover the cases in which the journals have become so hot as to make trouble; in cases of that kind they would have to be removed and not run in passenger service. It is not possible for me to say whether the use of water for cooling has anything to do with the breaking or not. It is my belief that a great many journals could be saved if we had Sam Weller's magnifying glasses, and could observe a journal when the first evidence of failure appears. If under those circumstances we could turn a stream of water on the journal, we would save a great many hot boxes, and a great many delays to trains. Unfortunately, however, the time for detecting the hot journal in transit is when the box begins to smoke and the waste begins to burn, and then it is rather late, although trainmen have to do the best they can under the circumstances. I know there are a great many advocates of the Cook Cooler, with which, under those circumstances they turn a stream of water on the journal; it is not a new device; the idea of running a stream of water on the journals is quite old, and we have got records running back a good many years on that particular

subject. It has never come into any very prominent use and mechanical men have always looked a little askance on the idea of getting a journal over the road on water instead of on oil. I am inclined to think there are a good many serious questions that need very careful consideration; and I hardly think that it is a subject that we can discuss offhand.

THE CHAIRMAN: Are the axles to which you refer made of steel or iron?

MR. BARR: Iron.

THE CHAIRMAN: I have had the same experience Mr. Barr has had with a journal that was broken off, and on investigating the cause I found that a day or two previous it had run hot and been cooled off; but it was impossible to say whether the breakage was due to the use of water on it while it was hot. I have been asked what caused a hot journal, and have had to say I did not know. I think that there is no man who can tell always what causes hot journals, and into what conditions they get before heating. They may be attributed to a great many causes; gritty substances, hard spots in bearings, seamy journals or separation of the waste from the journal. Our instructions concerning the removal of axles from passenger equipment are the same as Mr. Barr's—to remove from passenger service those that have had hot journals.

MR. DEEMS: In looking up the case of hot journals some time ago, I found some information in line with that which has been given. It was in the Proceedings of the Society of Mechanical Engineers, I think, in 1888 or 1890, and it appears that quite an extended series of tests were made. It was found that of test journals, journals which were kept thoroughly oiled, there being absolute uniformity in the manner of lubricating—one would run hot one day, and another would run hot another day, and so on. No explanation was offered as to why the journals ran hot, and though the conditions were identically the same day after day during the test, I felt a certain sense of satisfaction in finding that such a test could not determine the question, because we are called upon so often to answer it, and it is not always easy to supply a plausible theory.

MR. GRAHAM: Another point on which I would like information. I agree with Mr. Barr that it would be a good idea to cool hot journals only to a certain point, not to let the car stand and keep throwing water on until the journal was nearly cold before starting

again. There are quite a number of engines that are equipped with hose attached to tank, the hose extending down to the journal box, and I have known cases where very hot journals were cooled without injury by putting a little waste under the journal that had burned out, turning on the water and immediately continuing with the train without waiting for the journal to cool. I would like to know whether that would have any different effect, in regard to destroying the journal, than would have the operation of cooling the journal while standing. I have known of a great many hot journals on locomotive tenders, and which have been cooled by running water on them, but I cannot call to mind a journal having been removed on account of heating.

THE SECRETARY: The question has been asked, "What causes hot journals?" I think there is hardly a member of the mechanical department who has not had some reason to give for hot boxes, and sometimes the reasons given depend on the seasons. In the spring, when ballasting begins, we always look for a large increase in the number of hot pins and boxes, and at this season of the year it is always considered in place to charge the difficulty to the new ballast and the dust stirred up from it by passing wheels. Our records show, however, that the greatest number of hot journals are found in the month of February, just at the time when we might expect the smallest number and, so far, we have not a satisfactory explanation of the matter.

MR. BARR: We have been wrestling with that problem for a long time now. We have got an unusual increase in hot boxes in locomotives; we have passed through a season when the locomotives have been running for about three weeks with the journals practically encased in ice and frost all the time. We find on inspection of some of these boxes, at least, that the waste is almost saturated with water instead of oil, and we have just issued instructions that the work of packing boxes must be carefully attended to, the packing must be carefully investigated and if it is wet, the packing must be changed. One of the first results that I get from these instructions is that they change the packing on an engine, and the first trip after it is changed the journal runs hot. I do not know whether that proves anything or not; it may prove a great many things. It might prove that the person who packed it did not pack it well; I think that the person who packed it let some dirt get into it in removing the

waste on the top of the box and the dirt made the trouble, but during this very cold weather we have had the same increase in the number of hot boxes and we have attributed it to the moisture in the waste. We had one case where an effort was made to remove a bearing and it was necessary to take a chisel to chop the waste out before the box could be raised to get the brass out; that is rather a peculiar case, and I trust that we do not have many of that kind, but it was an actual occurrence.

As to the question of what causes hot boxes, I believe it would be a great deal harder to answer the question, "Why don't we have more?" When you consider the weight per square inch of bearing on every car running on our roads, and look at our mechanical appliances and find that we are carrying two or three times the weight per square inch it is safe to run journals on, and that we are making an average of forty or fifty thousand miles per car per hot journal, it seems to me that it would be a great deal harder question to answer if it were asked,—why don't we have more hot boxes than we actually have?

The Chair called for a report from the Committee on Recommendations.

MR. BARR: Mr. Chairman, that committee can only report progress. I understand that the committee is to report at the April meeting; I believe that it will be ready to report then.

Adjourned.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED, April, 1884.

INCORPORATED, March, 1897

MARCH 25, 1899.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 7.

CHICAGO, ILL.

\$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

JOHN W. CLOUD,
Westinghouse Air Brake Co.,
974 The Rookery, Chicago.

Directors:

H. G. HETZLER,
Supt. Fght. Terminals, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER.	JOHN W. CLOUD.
F. W. BRAZIER.	H. G. HETZLER.
PETER H. PECK.	F. W. SARGENT
PROF. WM. F. M. GOSS.	

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
St. Paul, Minn.
A. M. WAITT,
Cleveland, Ohio.

The regular monthly meeting of the Western Railway Club was called to order at 2 p. m. Tuesday, March 21, 1899, in the Auditorium Hotel, Chicago. President C. A. Schroyer in the chair.

Following are the names of those who registered:

Allen, F. J.	Jennings, D. F.	Schroyer, C. A.
Amory, E. P.	Keeler, Sanford.	Shea, R. T.
Barr, J. N.	Kerr, Prof. C. V.	Slater, F.
Breckinridge, Prof. L. P.	Kidder, S. J.	Smart, Prof. R. A.
Brown, Benson E.	Kirby, T. B.	Smith, J. L.
Bryant, W. E.	Kuhlman, H. V.	Smith, H. E.
Clifford, C. J.	Lowell, W. W.	Smith, F. P.
Cockfield, Jos.	Manchester, A. E.	Smith, R. D.
Coffey, J. D.	Marshall, W. H.	Street, Clement F.
Conger, C. B.	Morris, A. D.	Thomas, E. P.
Crosman, W. D.	Osborn, C. H.	Thompson, W. O.
Davies, W. O.	Otto, O.	Toppan, J. S.
Doebler, C. H.	Parisoe, L.	Tratman, E. E. Russell
Eames, Ed. J.	Paxton Thos.	Waitt, A. M.
Fildes, Thos.	Peck, P. H.	Wickersham, R. S.
Furry, F. W.	Pettis, C. D.	Wickhorst, M. H.
Gilleland, D. J.	Phillips, Walter.	Whipple, A. L.
Giroux, G.	Pratt, E. W.	Whitridge J. W.
Gowin, J. P.	Reiley, B.	Whyte, F. M.
Hatswell, T. J.	Rennolds, Wm. C.	Williams, J. C.
Herr, E. M.	Rogers, M. J.	Wood, J. L.
Hill, Jas. W.	Scales, R. P.	

THE PRESIDENT: The minutes of the February meeting have been printed in the Proceedings and if there is no objection they will stand approved as printed. Hearing no objection, they are so approved.

The Secretary will now read the names of those who have applied for membership since the February meeting and whose applications were acted upon favorably by the Directors at their meeting this forenoon.

The Secretary then read the following names:

Mr. Thomas Erickson, Gen'l Foreman, C. & N.-W. Ry., Baraboo, Wis.

Mr. Frank Hedley, Gen'l Supt., Lake Street El. Ry, Chicago.

Mr. Edw. H. Lee, Chief Engineer and Roadmaster, C. & W. I. Belt Ry., Chicago.

Mr. John G. McLaren, M. M., C. & E. Ry., Huntington, Ind.

Mr. Chas. W. Melcher, Western Manager, Ingersoll-Sargent Drill Co., Chicago.

Mr. M. Mercatoris, Gen'l Foreman, L. & C., C. & E. Ry., Chicago.

Prof. R. S. Miller, Purdue University, Lafayette, Ind.

Mr. A. R. Raymer, Ass't. Chief Engineer, P. & L. E. Ry., Pittsburgh, Pa.

Mr. F. P. Rugh, Coal Inspector, B. & M. R. R. R., Lincoln, Neb.

Mr. W. D. Scott, Engineer, St. L. & S. F. Ry., Monett, Mo.

Mr. F. R. Spear, President, Allen & Morrison Brake Shoe Mfg. Co., Chicago.

Mr. Samuel Stewart, C. L. S. & E. Ry., Chicago.

THE PRESIDENT: The next order of business is unfinished business; there being no unfinished business, we will pass to reports of committees.

THE SECRETARY: There are two committees to report and it is understood that their reports will be ready for the next meeting, the same to be printed in the advance sheets. One is the committee which is investigating the question of a standard knuckle for couplers, and the other is the committee to suggest changes considered desirable to make in the interchange rules.

THE PRESIDENT: New business is next in order.

THE SECRETARY: There is a communication from Professor Wm. F. M. Goss, but I wish to explain before reading it that it is probably submitted because Professor Goss is going abroad soon to be absent for several months; however, I am not directly informed that this is the reason.

LAFAYETTE, IND., March 18, 1899.

To the Board of Directors, Western Railway Club:

GENTLEMEN—As I shall be unable to take part in the work of the Western Railway Club during the remainder of the Club year, I submit herewith my resignation as second Vice-President of the Club. I urge its acceptance, and the election of a successor, in order that the Club may be fully officered by men who can be active in attending to its affairs.

Acknowledging the courtesies I have enjoyed through the indulgence of Directors and members, I remain with best wishes,

Very truly yours,

WM. F. M. GOSS.

THE PRESIDENT: The communication was presented to the Directors this morning and they advised that it be read to the Club for action. The laws of this state require that a corporation shall have seven directors, and inasmuch as we are incorporated, if the Club elects to accept Professor Goss' resignation as second Vice-President it will be necessary to fill the vacancy by an election. What is your pleasure? Whatever action is taken there should be some expression by the Club of its appreciation of the services rendered by

Professor Goss; he has been one of the hardest workers we have ever had in our Club.

MR. A. M. WAITT: Mr. Presiden, it seems to me, in view of the fact that Professor Goss has been, as you have just stated, an earnest and interested worker for and with the Club for a number of years, and he has filled very acceptably the position to which he has been elected for two years past, that we need not be under the necessity of accepting his resignation. I think the Club is pretty well officered, and I think there are not any laws of the Club preventing an officer taking a vacation trip to Europe, and I, for one, would feel opposed to taking any action accepting his resignation. Our Club is honored in having him as one of its officers, and I hope he may remain so during the balance of the year. As we have only two more business meetings for the year, I think that we will not suffer, and I believe the honor that comes in having such a man in our Board of Directors and as an officer is sufficient reason for not accepting the resignation.

MR. CLEMENT F. STREET: I wish to second the remarks of Mr. Waitt, and I move that the Secretary be instructed to write Professor Goss and request that he withdraw his resignation and continue to act as second vice-president. I believe that Professor Goss in Europe will make a better Vice-President for the Club than some we might elect and who will remain in this country. (Seconded.)

THE PRESIDENT: Mr. Street's motion has been seconded. All in favor of the motion will give their assent by saying "aye."

Carried unanimously, and the Secretary is instructed accordingly.

The next order of business is the presentation of the papers which have been printed in the advance sheets. The first paper is on the subject of "Compound Locomotives on the Northern Pacific Railway," by Mr. Edwin M. Herr.

COMPOUND LOCOMOTIVES ON THE NORTHERN PACIFIC RAILWAY.

BY MR. EDWIN M. HERR.

The record of the compound locomotive on the Northern Pacific railway is of interest on account of the number of different systems of compounding employed, the different sizes and types of locomotives compounded, as well as the wide variation in the topography of the road over which they are run, and the kind of service in which they are employed. Through the courtesy of Mr. Wm. Forsyth, Supt. M. P., Nor. Pac. railway, the following data has been obtained:

DESCRIPTION OF COMPOUND LOCOMOTIVES.

The systems of compounding include the Vaucrain four-cylinder type, built by the Baldwin Locomotive Works, the two-cylinder type as built by the Richmond Locomotive Works, the Pittsburgh Locomotive Works, the Brooks Locomotive Works and the Schenectady Locomotive Works.

The sizes and types of compound locomotives range from a mogul weighing 85,000 pounds on drivers, with 19 and 27x24-inch cylinders, to a mountain consolidation weighing 166,000 pounds on drivers, with 23 and 34-inch diameter cylinders by 34-inch stroke, and include ten-wheel engines for both passenger and freight service, weighing respectively 112,000 pounds, and 126,000 to 132,000 pounds on drivers, as well as consolidation engines with 135,000 pounds, and mastodon type engines with 150,000 pounds on drivers.

In Table 1 is given the principal data of each of these engines, the number of each kind and the date the first of each type went into service. Below in the table, the same information is given of the simple engines, with which any of the types of compounds can be compared.

This comparison to be of value must be made understandingly, as it will be noted that in no case is the simple engine in all respects like the corresponding compound.

The D³ and F¹ compound engines are the same as the D³ and F¹ simple, excepting the cylinders and other compounding features. They are, in fact, the same engine with compound cylinders attached in place of the original simple cylinders, and the boilers strengthened to carry 180 instead of 150 pounds of steam. The D⁵ compound engines are identical with the same class of simple engines, except the cylinders and other compounding features, all this class of engine, both simple and compound, having new boilers carrying 200

pounds of steam. The simple engines, however, were only worked at 180 pounds. The Class P compound engines are also identical with the corresponding simple engines except the cylinders and other compounding features.

The changes from simple to compound, even if the engine is otherwise identical, make the compound heavier by the additional weight of cylinders. These excess weights are estimated in the table, except in the case of the D⁵ engine.

The weights of the new Schenectady engines are actual weights, excepting the Class Y, which is as estimated by the builders.

KIND OF LOCOMOTIVES DISPLACED BY COMPOUNDS.

In going into service these compound engines displaced simple engines of various types and weights as follows:

The D³ mogul compounds replaced similar simple moguls carrying 150 pounds of steam.

The D⁵ moguls replaced D³ moguls carrying 150 pounds of steam; but as the D⁵ moguls are both simple and compound, a comparison is made between these engines as well as between each of them and the simple D³ moguls carrying 150 pounds of steam which they replaced.

The F¹ mountain consolidation engines partly replaced similar simple mountain consolidation engines, and one of them also was run in the same service with the mountain mastodon compound engines, Class X. A comparison with both is therefore given.

The Class P passenger ten-wheel compounds replaced simple ten-wheel passenger engines, but as the engines replaced were very much lighter (weighing only 81,000 pounds on drivers, with much smaller boiler and lower steam pressure than the Class P engines), no comparison of value can be made. The performance of the smaller simple ten-wheelers for the two months immediately preceding their replacement by the Class P simple and compound engines is shown merely as a matter of interest. Comparison is made only between the simple and compound Class P engines in the same service.

The Class R engines also have no comparable simple engines, and are therefore shown on two districts of the same division differing considerably in gradients. As with the Class P engines, the performance of the engines replaced (which in this case were the Class D³ moguls), is shown for the two months preceding the Class R's first going into service.

The Class S and Class Y engines have so recently gone into service that no data as to their performance is shown.

The Class X engines replaced simple Class F¹ mountain consolidation engines carrying 150 pounds of steam. They are also compared with the compound Class F¹ mountain consolidation engine carrying 180 pounds of steam.

CHARACTER OF SERVICE.

The D³, D⁵ and Class R engines are all in through freight service on divisions where little local business originates, and therefore are called upon to do but little switching. The D⁵ engines have more switching to do than the other two,

but even they are required to do comparatively little. The trains the D⁵ draw are carded to make 14.6 miles per hour east bound, and west bound 16.3 miles per hour. Those hauled by the D³ compounds are carded 13.2 miles per hour east bound, and 13.7 miles per hour west bound, all on single track with frequent meeting points. The Class R engines on the second and third districts of division, between Spokane and Pasco, and Pasco and Ellensburg, were generally the Idaho used on express freight trains carded between the two former points east bound 15.3 miles per hour, west bound 17.5 miles per hour; between the two latter, east bound 17.7 miles per hour, west bound 13 miles per hour.

The Class P engines are used in passenger service exclusively, those the performance of which is shown on Plate D, running between Spokane and Ellensburg. This is a continuous run of 273 miles with heavy trains of ten to fifteen cars, stopping at nearly all stations, and in the summer and fall loading large quantities of express matter. The train west bound was carded 28.7 miles per hour, east bound 32.7 miles per hour in 1897. Early in 1898 speed was increased to 29.5 west bound, and decreased to 30.3 miles per hour east bound. The engines in this service make about 8,600 miles per month and are all either double or triple crewed.

The Class F¹ and Class X engines are used exclusively as mountain helping engines. The data given on Plate E for these engines is on Helena mountain—see Profile E. This is the grade where the main range of the Rocky Mountains is crossed and on the east side is continuous 2.2 per cent., or 116 feet per mile, for eighteen miles, with much curvature as sharp as 10°. Speed is low, from four to twelve miles per hour on the upgrade. Table 2 also gives the result of tests with these engines on Bozeman mountain near Livingston, (Profile F). The grade and curvature are about the same, viz., 116 feet per mile maximum, and 10° as on Helena mountain, but the length is only about twelve miles instead of eighteen.

GRADES AND GENERAL DESCRIPTION OF LINE.

The grades upon which the performance shown on Plates A to E was made are found on Profiles A to F.

The profiles are in general lettered to correspond with the plates showing the engine performance. On Plate D, however, is shown the performance of Class P engines running not only over the district shown on Profile D but that on Profile C also. On Plate C is shown the performance of Class R engines on district given on Profile C; in full lines and in broken and dotted lines same class of engines on the district between Pasco and Ellensburg shown on Profile D.

The performance of Class X mastodon and Class F¹ mountain consolidation engines on Plate E was made on road shown on Profile E. In Table 2 the results of tests between Livingston and Muir were obtained over part of line shown in Profile F.

The road shown on all above profiles is single track and, excepting over mountains, runs through a more or less rolling prairie country almost devoid of trees and entirely so of forests or other obstructions to the winds, which in

northern Minnesota (Profile B) and eastern Montana (Profile A) often seriously interfere with the movement of trains. The winter temperature in these districts is very low, often ranging between 0 and 20 degrees below for weeks, while the winds cause the locomotive performance to suffer, not only from their own force, but in winter from the obstruction of the track by drifting snow. It should be stated, however, that the winter of 1897-'98 was an exceptionally mild one in these regions, and but little difficulty was had either with cold or snow.

In districts shown on Profiles C and D, between Spokane and Ellensburg in Washington, the winters are generally mild and but little snow or wind is experienced. Over the mountain districts, Profiles E and F, while the winters are cold no large amount of snow falls, and high winds are almost unknown.

PERFORMANCE OF COMPOUNDS.

The performance of locomotives on the Northern Pacific railway is determined by the number of pounds of coal consumed per 1,000 ton miles of train hauled, including the engine and tender, and if of a freight train the caboose also. As the size of the train hauled has a very considerable effect upon the performance figured as above, the weight of the average train hauled is also shown on the monthly performance sheet. On Plates A to E are plotted the performance of certain compound locomotives, and where possible to make comparison, that of simple locomotives doing the same service. The average train hauled is also plotted for each. The points so laid down for a series of months are joined, giving a curve showing graphically the performance and average train for as long a period as reliable data is at hand. Where a comparison between simple and compounds can be made, the percentage of saving in fuel of the compounds is also plotted.

Plate A gives the average performance, average train and economy over the simple Class D³ locomotives of the four converted Class D³ mogul compounds on the first district of the Montana division between Billings and Livingston, shown on Profile A. On this plate the four compounds are averaged and the average performance of all is shown in full lines. The average performance and average train of all the simple Class D³ locomotives running in the same service on this district are shown by dotted lines. The performance of each individual compound of the four different types is shown on Plate A¹, with the same curve of average performance of the simple engines in dotted lines as is shown on Plate A. An examination of each of the lines will show that no one compound shows uniformly the best performance, although compound D makes considerably the best average. This compound was always operated without using high pressure steam in the low pressure cylinder to start the train and while, as the plate shows, the economy was good, frequent delays and stalling in different places caused this feature to be seriously criticised by the operating officers. Of the relative economy of the others, all of which used high pressure steam in the low pressure cylinder when starting, it would be difficult to choose. The average train each month is not plotted, owing to the confusion of lines, but the general average of the trains hauled during the seventeen months is shown.

Profile A shows the work west bound on this district is continuous and almost uniform, the road gradually ascending 1,375 feet in 115 miles. This is quite a favorable section for the compound, although not as favorable as a division where the engine can be more nearly fully loaded each way, as is the case in the performance shown on Plate B. The economy shown in the above case is over simple engine carrying 150 pounds of steam, while the compound carried 180 pounds.

None of the compounds had been through the shop since they were converted, and it is interesting to note that the economy was well maintained until September, 1898, when they had averaged nearly 90,000 miles each; although in the last few months shown, the performance of the compound does not compare as favorably as in the early part of their service.

The cost of running repairs, with the mileage made between April 1, 1897, and September 30, 1898, for compound and simple engines compared with them is as follows:

ENGINE	ENGINE MILES	GROSS TON MILES	REPAIRS PER ENGINE MILE	REPAIRS PER 1000 G. T. M.
Compound Engine A	56886	42,146,900	\$.0161	\$.0217
“ “ B	60234	49,070,628	.0154	.0182
“ “ C	54497	42,404,236	.0154	.0198
“ “ D	51248	40,544,366	.0121	.0153
Simple Engine 507..	52915	31,400,344	.0166	.028
“ “ 520..	63234	38,163,393	.012	.0198
“ “ 566..	52738	34,612,835	.0184	.0284

Plate B shows in the same manner the performance of Class D⁵ compounds and simple engines, and also the performance of Class D³ simple engines on the second district of the Minnesota division between Staples and Fargo. Here the performance of the one compound D⁵, engine 410, is shown in full lines; that of the simple D⁵ engines 430, 431 and 432 is averaged and shown in dotted and broken lines (— . — . — .), and the performance of the simple Class D³ engines in dotted lines. The average trains hauled by each are similarly plotted. The curves showing percentage of economy of compound D⁵ over simple D⁵ is in broken and dotted lines; over the simple Class D³ in dotted lines. This section of road is very favorable to the compound, as will be seen from Profile B, especially when it is explained that at Winnipeg Junction the traffic from the Manitoba division meets the main line, enabling trains to be filled up at this point in both directions. The record of the compound here is quite remarkable, averaging 28.4 per cent. economy over the simple engines of the same class carrying 180 pounds steam pressure, and 35.7 per cent. economy over the lighter moguls carrying 150 pounds steam. It should be noted that the compound hauled somewhat heavier train than the simple, and very decidedly heavier than the D³ engines, which would assist in improving its economy compared with engines hauling lighter trains. The cost of running repairs for these engines can scarcely be compared in value with those of the Class D³ engines, as the D

engines have only made a total of about 30,000 miles each up to September 30. The repairs of the compound and simple Class D5 engines, all of which have been in service the same length of time, can be fairly compared, and are as follows:

January 1, 1898, to September 30, 1898.

ENGINES	ENGINE MILES	GROSS TON MILES	REPAIRS PER ENGINE MILE	REPAIRS PER GROSS TON MI.
Compound D5, No. 410	19357	22,879,392	\$.0138	\$.0116
Simple, D5, No. 430 ..	23835	27,697,742	.013	.0112
" D5, " 431 ..	24215	25,493,019	.0148	.0141
" D5, " 432 ..	20858	24,051,100	.022	.0191

It should be stated that owing to ballasting during the month of August engine 410, the compound D5, was laid up, as there was ample power without this engine, whose L. P. cylinder caused trouble, striking ballast unloaded near track. This accounts for the low engine mileage compared with the simple engines of the same class.

Plate C gives the performance of the first two Class R engines built for the Northern Pacific railway. in freight service on the Idaho division, second district, between Spokane and Pasco, plotted in full lines and in broken and dotted lines, the same class engines going into service three months later on the third district of the same division, viz., between Pasco and Ellensburg, all in the state of Washington. The Profile of each of these districts is shown on Profiles C and D respectively. On Plate C is also shown, in dotted lines, the performance of Class D3 engines. The engines ran either on the first and second districts of this division or on the third district. The latter only are hauling trains over the same track as the Class R engines shown in broken and dotted lines. It may be noted, however, that the grades on the first district are much easier than on the second district, so that locomotives working on both first and second districts have the advantage of those on the second district alone. The performance of the Class R engines on this plate cannot be compared with that of any simple engines, as all the simple engines in freight service were displaced by them. It is interesting to note, however, that the performance of the engines on the second district during the summer months of 1898 is not as good as during the corresponding months of 1897. This indicates that these compound locomotives, after making upwards of 70,000 miles in heavy service, were becoming less economical to the extent shown. Such conclusion is, however, not entirely correct, as the quality of the coal used during the summer of 1898 was inferior to that used during the corresponding months of 1897, being in 1898 largely composed of fine screenings, while in 1897 lump coal from the same mines was generally furnished. After making the above mileage, at the average rate of about 4,400 miles per month, hauling trains averaging upwards of 1,000 tons on long stretches of 1 per cent. grade, it is not to be expected that the engines were as economical as when first put in service, and when the poor quality

of coal used is considered their relative performance is good. The effect of the poorer coal in July and August, 1898, is also seen on the Class R engines on the third district, which had neither been in service as long nor made as large a monthly mileage as those on the second district. The variation in average train hauled was principally due to change in the volume of business, as the winter was not severe enough to materially affect the average train hauled. The cost of running repairs on the Class R engines on the second district, with the mileage made between July, 1897 and September, 1898, as well as ton miles hauled, is given below.

ENGINE	ENGINE MILES	GROSS TON MILES	REPAIRS PER ENGINE MILE	REPAIRS PER GROSS TON MI
Class R, Engine 170..	70,255	69,901,091	\$.019	\$.0191
“ “ “ 171..	70,151	70,411,387	.0186	.0186

On Plate D is shown the performance of both the simple and compound Class P engines in passenger service between Spokane and Ellensburg. This, as before stated, is a continuous run of 273 miles, over two districts of the Idaho division, shown on Profiles C and D. The coal record of the compound engine 200, together with the average train hauled by it, and the per cent. of coal saved by it, over the simple Class P engine 220, are shown in full lines; the corresponding coal record and average train of the simple engine 220 being shown in broken and dotted lines. It will be noted that the average train hauled is upwards of 500 tons, and in the latter part of 1898 upwards of 550 tons. This means very heavy work on the second district east bound, and on parts of this district west bound also. In only two months out of the fourteen for which we have comparative records, did the compound fail to show economy over the simple. An investigation of the cause in each case, made at the time, brought out the fact that the compound locomotive in both these months happened to catch badly delayed trains, with which time was made up in bad weather and with a poor quality of coal, while the simple engine in these two months happened to catch trains more nearly on time and made up much less time. In July, 1898, the reverse conditions existed, resulting in an exceptional record in favor of the compound. The average economy for the entire period, viz. 14.6 per cent., is probably nearly what might be maintained. It must be remembered, however, that this can only be expected in rather unusually heavy passenger service. It will be noted that the smaller average train in the last months of 1897 and January and March of 1898 resulted in smaller saving by the compound, while with the increase of train after March, 1898, the relative economy of the compound improved.

The record in the month of August, 1898, was made after the compound had made over 100,000 miles (the simple over 90,000 miles) in the above service with only ordinary roundhouse running repairs.

The average cost of repairs is given below, together with mileage made and ton miles hauled from June, 1897 to September 30, 1898.

ENGINE	ENGINE MILES	GROSS TON MILES	REPAIRS PER ENGINE MILE	REPAIRS PER GROSS TON MI
Compound, Cl. P, 200.	106473	57,450,095	\$.0226	\$.042
Simple, Class P, 220.	95347	50,361,863	.0228	.0431

The simple engine making less mileage was at some disadvantage in the matter of repairs, but the indications are that as far as the running repairs are concerned the compound will cost no more. Both engines were always double, and often triple crewed, and that no advantage in service or repairs was given the compound, the above record of mileage repairs and performance clearly shows.

Plate E shows the average performance of four compound mastodon engines, Class X, from April, 1897, to July 31, 1898, and also compound consolidation F¹ engines for the months of July, August and November, 1897, and simple consolidation F¹ engines for months of April, May and August, 1897. In order to avoid confusion of lines showing coal consumed and the average train, two base lines are used, the upper line being for the coal per 1,000 ton miles, the lower for the average train in tons. It will be noted here that the coal burned per 1,000 ton miles is much greater than in any service previously shown, amounting one month to 391 pounds per 1,000 ton miles for simple engines.

The performance of the F¹ compound is practically the same as the mastodon in coal per 1,000 ton miles, and when the smaller average train hauled by the former is considered, the steam economy is undoubtedly better than that obtained by the heavier mastodon. The better economy of the four-cylinder compound in this service and not in the ordinary road service, when compared with the two-cylinder compounds, is doubtless due to the engines in mountain service being worked almost always so nearly full stroke that the cylinder ratio of the two-cylinder compound does not give expansion enough to reach the point of greatest economy, while the four-cylinder compound, having a larger cylinder ratio, more nearly approaches it. The profile of the part of the road upon which the performance on Plate E was made is shown on Profile E between Helena and Elliston. Plate E, like all the other plates, was plotted from the monthly performance sheets and shows the performance of the engines for which the results are given in regular daily service over the sections of road indicated.

It is interesting in mountain service to compare the results of the up-hill work with the performance of locomotives running in both directions, and for this purpose, and also to still further compare the work of a simple and compound locomotive under various conditions Table 2 is given.

Here are tabulated the results of a series of tests made by Mr. A. Lovell in April, 1897, of three of the four mastodon Class X engines, whose performance is shown on Plate E, and Class F¹ simple mountain consolidation engine 494. All tests, except one, that of Class X engine 14, were made from Livingston to Muir (see Profile F); that of engine 14 from Helena to Blossburg (see Profile E.) The grades are practically the same, 2.2 per cent. maximum, but in the former case the distance is twelve miles; the latter about eighteen miles,

with more curvature. The great increase in consumption of coal in all engines over that shown in regular up and down-hill work is very striking, the compound in one case reaching a consumption of 853 pounds of coal per 1,000 ton miles, the simple 1,339 pounds.

The cost of repairs for each of the mastodon Class X engines and the four-cylinder compound Class F¹, from May 1, 1897, to September 1, 1898, is as follows:

ENGINE	ENGINE MILES	GROSS TON MILES	REPAIRS PER ENGINE MILE	REPAIRS PER 1000 G. T. M.
Class X, No. 13	27,159	17,328,907	\$.0307	\$.0521
“ “ “ 14	30,950	19,231 253	.028	.046
“ “ “ 15	32,323	19,717 432	.0236	.0383
“ “ “ 16	29,496	18,802,336	.0284	.0451
Comp., Class F ¹ , No 50	27,997	15,315,493	.028	.0513

All the Class X engines were originally furnished with cast iron wheels under the tender. The brake service was so severe on this long 2.2 per cent. grade that it was found desirable on account of cracked plates to replace these cast iron with steel tired tender wheels, which was done about January 1, 1898. The cost of steel tired wheels is not included in above cost of repairs nor is the cost of repairs on account of wrecks, but the expense incident to maintaining the cast iron wheels on tender before they were replaced is included. With the exception of engine 13, which was derailed and turned over, none of these engines had \$50.00 worth of work done on them on account of wrecks. They were held out of service on account of light repairs as follows during the seventeen months for which cost of repairs is given: Engine 13, fifty-two days; engine 14, nineteen days; engine 15, three days; engine 16, twenty-six days; and engine 50, forty-four days. Some of these periods may seem long, but engines were located 123 miles from the nearest shop and upward of 1,000 miles from a foundry and heavy forge shop, causing unavoidable delay to work requiring castings or heavy forgings. It is unfortunately impossible to give any comparison with repairs on the simple Class F¹ mountain engines during the same period, as none were in service on Helena mountain grades.

The tests in Table 2 indicate about the quality of coal used at these points for locomotive purposes. It will be seen that the evaporative power of the Red Lodge coal varied considerably in the different locomotives tested, the compounds showing better evaporation than the simple. This is generally true and is one of the causes of the greater economy of this type of locomotive.

As the evaporative quality of the coal used must be known before proper comparison can be made of the performance of locomotives burning different kinds of fuel, the evaporative values of all the principal coals used on the Northern Pacific railway locomotives, with the divisions on which each is used, is given below. The evaporative value is that determined in an elaborate series of tests of twenty-seven different bituminous coals, made under stationary boilers and on both mogul and consolidation locomotives, by Mr. A. Lovell, then engineer of tests, Northern Pacific railway, about two years ago, and supplemented by

careful analysis and determination of the theoretical evaporative value. As the results obtained from the stationary tests are probably the most accurate, they are given together with the theoretical evaporation from and at 212 degrees—see Table 3.

The above tables and data show the steam engine performance, fuel economy and cost of repairs of the compound locomotives. In comparing the results given above, the much larger size and greater horse power or capacity must be remembered. A locomotive is usually considered a locomotive, regardless of its size or capacity. Plate G gives the actual horse power developed by some of the locomotives shown at various speeds, together with curves of equal horse power at the different speeds and resistances. These curves of locomotive horse power were plotted from a large number of indicator cards taken under various conditions of speed and cut off always with full throttle, and are believed to represent about the maximum horse power the different engines are capable of sustaining continuously under service conditions, and, as all are determined alike, are at least believed to be fairly comparable. The horse power curve of the Class R compound is probably too low in its lower portion, as on account of its smaller driving wheels it will undoubtedly give higher horse power at slow speeds than Class P. The wide gap between the power of the old mogul D³ engines and the heavier new Class P and R engines is very suggestive, as is also the increase in power of the Class X over the old Class F¹ mountain consolidation.

NOTES ON THE DESIGN AND MAINTENANCE OF COMPOUNDS.

Many railroad mechanical men, while freely admitting that the compound locomotive in heavy freight service will prove more economical in the consumption of coal than the simple engines of the same weight boiler capacity, steam pressure and general design, give as their reason for not advocating the compound locomotive for such service, its liability to failure on account of breaking down, increased cost of maintenance and consequent longer enforced idleness. Were the failure of compound locomotives generally in the compounding features, and were such failures difficult to remedy, such objections to the use of such locomotives would have great weight. The intercepting and separate exhaust valve, where present, the receiver in the two-cylinder type, and the larger low pressure cylinders are the peculiarly compound features. Investigation will show that the increased cost of maintenance and general unsatisfactory performance is not on account of broken intercepting valves, leaking receivers, or difficulty in packing or counterbalancing the low pressure cylinder. Failures occur on account of broken frames, broken cylinders, unequal wear on the low and high pressure sides of the engine, broken piston rods, cut high pressure valves and consequent break-downs in the valve motion, cut and badly worn cylinders and other causes, practically all of which are clearly traceable to either bad design, construction, or improper care in maintenance. It would seem an admission of inability to cope with the engineering problem of the design of the compound locomotive, or the administrative ability to care for a machine which is acknowledged to save a considerable

proportion of the largest single item of expense on a railroad, to refuse to use such a machine because it breaks down. Is it not rather the duty of railway mechanical officers to study the causes of failure in such machines, and by remedying such defects as develop in existing types, learn to design a compound locomotive so strengthened in the weak places and modified in those of impractical construction that it will not fail in service. This accomplished, a further careful observation and effort to learn how to so care for and operate this more economical machine will soon enable its cost of maintenance to be reduced, just as long years of practice and care have done in the repairs of the simple locomotive.

No one realizes more keenly than the writer, that the problems above referred to are by no means easy. The importance of knowing exactly what difficulties are experienced in regular operation and immediately applying some remedy for every defect cannot be too strongly impressed. The old adage "a stitch in time saves nine" was never more apropos than in caring for a compound locomotive. It should be remembered in considering the above data that all of the compound locomotives, the performance of which is shown, have yet to receive their first general repairs. They are all comparatively new, but none have received any special consideration in the conditions under which they have thus far seen service; in fact, all master mechanics were instructed to put the compounds to the hardest test and always favor the simple engines in case conditions were not the same. Their performance in ton miles indicates that these instructions have been carried out. The exact facts as to the general design, conditions of operation and the results obtained, both as to performance, fuel economy and running repairs, have, it is believed, been faithfully given. If the data presented will bring out a full and free discussion of the relative value of the compound locomotive in heavy service the object of the paper will have been attained.

Table 3

COALS USED ON N. P. LOCOS., EVAPORATIVE VALUES.

NAME OF COAL	DIVISION ON WHICH USED FOR LOCO. FUEL	Evaporation Lbs. Water per Lbs. Coal from and at 212°		Per cent. Ash	
		Theoret'l from Analysis from and at 212°	Evapor'n under Sta. Boiler from and at 212°	From Analysis	From Sta. Tests
Youghiogheny	{ Minnesota, Dakota } { Manitoba..... }	14.351	7.59	7.95	10.07
Red Lodge.....	Yellowstone & Montana	10.926	7.18	9.04	13.66
Roslyn.....	{ Rocky Mts., Idaho and } { Pacific..... }	12.821	7.33	14.34	18.93
Chestnut.....	Montana Div.....	12.542	7.14	12.76	17.53
Hocking.....	{ Minnesota, Dakota and } { Manitoba..... }	12.248	7.21	8.60	11.50



Spokane

10

0

0

115.

PRINCIPAL DATA OF N. P. COMPOUND LOCOMOTIVES,
AND SIMILAR SIMPLE LOCOMOTIVES.

CLASS	Date First in Service	STYLE	BUILDERS AND STYLE OF COMPOUND IF CHANGED.	Type of Comp.	Number of Engines in Service	CYLINDERS			FOILER					ENG. DIMENSIONS					Total Wheel Base Engine and Tender	WEIGHTS LOADED IN WORKING ORDER				Steam Pressure		
						H. P. Dia.	L. P. Dia.	Stroke	Grate Surface	Heating Surface			Dia. Shell	Type	Dia. Drive Wheels	Dia. Truck Wheels	Rigid Wheel Base	Total Wheel Base		On Drivers	On Truck	Total Eng.	Total Engine and Tender.			
										Fire Box	Tubes	Total														
D-3	1-97	Mogul	Baldwin Simple changed to Richmond Comp.	2 Cyl.	1	Inches	Inches	Inches	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Inches	Ext.	Inches	Inches	Fl. In.	Fl. In.	Fl. In.							
"	1-97	"	" " " " Pittsburgh " "	2 "	1	19	29	24	16.77	130	141.9	1549	56	Wacoa.T	56	30	15-3	23-4	45.3	85.00	18500	104400	175300	180		
"	1-97	"	" " " " Baldwin " "	4 "	1	19	29	24	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
"	1-97	"	" " " " Baldwin " "	4 "	1	19	29	24	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
D 5	11-97	"	Baldwin Simple with new boiler changed to Baldwin Comp.	2 "	2	19	30	24	18.4	145	1601	1746	58 1/2	"	"	"	15-8	23-9	"	102000	"	120500	191500	200		
P-1	9-96	Mountain Consol.	" " " " " " " " " " " " " "	4 "	3	15	25	28	35.3	167	2154	2321	72	Straight	40	"	14-0	22-3	49-2	138000	20600	156000	235600	180		
P	6-97	Ton-Wheel Pass.	New Schenectady Compound.	2 "	9	22	34	26	30.8	203	2332	2535	62	Ex.W.T.	69	33	14 1/2	23 1/2	52 2	112400	43500	175500	249500	260		
R	8-97	" Freight	" " " " " " " " " " " " " "	2 "	20	29	34	26	34.2	240	2655	2935	70	Ex.W.T.	63	30	14-0	25-11	53-9 1/2	124000	46500	170500	244500			
Z	5-98	" " "	" " " " " " " " " " " " " "	2 "	8	22	34	28	34.2	240	2655	2935	70	"	63	30	14-0	25-11	53-12	131800	42000	173800	267800	"		
N	2-97	Mountain Mastodon	" " " " " " " " " " " " " "	2 "	4	23	34	30	35	222	2722	2944	72	"	55	28	15-6	26-4	53-8	150000	36000	186000	276700	"		
N	1-98	" Consol.	" " " " " " " " " " " " " "	2 "	14	23	34	34	35	222	2706	2928	72	"	55	30	14-8	23-3	51 9/2	166000	20000	186000	298000	21		

SIMPLE LOCOMOTIVES WITH WHICH ABOVE COMPOUNDS CAN BE COMPARED.

D 3	Mogul	Baldwin	95	18	24	16.77	130	1419	1519	56	Ex. W. T.	56	30	15-3	23-4	45 3	85000	15000	100000	170900	150
D 5		" with new boiler	3	18	24	18.4	145	1601	1746	58 ¹ ₄	"	56	30	15-8	23-9	45-3	93600	15000	108000	179600	180
P-1	Mountain Consol.	"	29	22	28	35.3	167	2154	2321	72	Straight	50	30	14-0	22-3	49 2	135000	15000	150000	227600	200
P	Ten-Wheel Pass r.	Schoenectady	9	20	26	30.8	203	2332	2535	62	Ex. W. T.	69	33	14-10	25-10	52 2	110000	38000	148000	242000	150

Table 2.

COMPARATIVE TESTS OF CONSOLIDATION AND MASTODON ENGINES ON MONTANA AND ROCKY MT. DIVISIONS.

APRIL, 1897.

[illegible]

LIVINGSTON TO MUIR — USED RED LODGE COAL.

3	Cl. F-1 494	536.15	24	42	7	8	15.7	9.	7.52	12.60	618.2	569.8	876.5	767.2	3.95	4.82	.980	1020.	Light head wind. Dry rail. Engine slipped some.
4	" "	498.95	23½	40½	8	8	15.	9.3	7.69	12.38	603.5	614.6	881.2	870.0	3.97	4.87	.962	1339.	Light head wind. Dry rail. Slipped very little. O. K.
5	" "	385.10	19	26	7	8	20.7	13.8	5.34	9.50	578.6	622.7	886.8	949.4	4.35	5.30	1.084	922.	Calm. Dry rail. O. K.
10	" "	383.90	19	31	8	7	19.6	12.1	5.79	8.44	587.5	542.8	856.2	819.2	4.06	4.90	.960	1042.	Calm. Dry rail. O. K.
Average.....		451.02	21½ ₁₀	34 ⁹ ₁₀	....	....	17.7	11.	6.58	10.48	596.9	594.2	875.2	851.4	4.08	4.97	.996	1081.	
7	Cl. X. 16	604.25	27	77	7	8	14.8	5.3	8.83	13.97	666.1	427.3	953.0	599.4	6.24	7.59	1.795	579.	} Very light head wind. Dry rail. Slipped and stalled twice above Hoppers. Pulled out simple. } Calm. Dry rail. Stalled once below Hoppers account sand pipe stopping. } Very light head wind. Dry rail. O. K. } Calm. Dry rail. Lubricator H. P. Cyl. failed to work. Stopped three times. } 46 per cent. economy over Engine 494.
8	"	578.40	21½	53½	8	8	16.9	7.4	8.07	12.49	713.	490.1	1061.3	671.2	5.16	6.31	1.805	554.	
6	"	385.10	16	20	7	6	20.7	15.9	5.95	8.87	771.6	750.7	1199.1	1167.8	5.82	7.08	1.568	637.	
9	"	383.90	18½	27½	7	7	20.7	15.	6.39	8.91	690.7	708.8	1152.6	1019.6	6.10	7.42	1.748	572.	
Average.....		487.91	20 ⁷ ₁₀	44½	....	....	19.3	10.9	7.31	11.06	710.3	594.2	1091.5	864.5	5.83	7.10	1.729	585.	
14	Cl. X. 13	579.05	21½	49½	7	8	19.1	6.5	7.91	12.77	781.8	436.5	1117.9	598.2	4.99	6.10	1.290	775.	} Some head wind. Dry rail. Stated Dist. B. account running simple too long. } Very light head wind. Dry rail. O. K. } Some side wind. Dry rail. Run slow Dist. A., fast Dist. B. } Some side wind. Dry rail. Run fast all the way.
15	"	536.05	18	34	7	8	21.1	10.9	7.63	11.49	841.4	662.6	1232.6	975.2	9.81	5.88	1.527	655.	
1	"	382.70	17	24	7	8	22.	15.	5.67	8.41	656.3	666.2	1062.0	1069.7	5.18	6.26	1.563	640.	
12	"	382.70	16	21	7	7	24.9	16.9	5.84	8.27	751.6	746.6	1184.3	1143.7	4.25	5.16	1.172	853.	
Average.....		310.12	18½ ₁₀	32½ ₁₀	....	....	21.8	12.3	6.76	10.23	757.8	628.0	1149.2	946.7	4.81	5.85	1.388	731.	32 per cent. economy over Engine 494.

HELENA TO BLOSSBURG — CHESTNUT COAL.

18	Cl. X. 14	561.87	39	88	5	11	15.9	8.2	6.82	Draw Bar Broke	536.2	Draw Bar Broke	867.9	760.9	5.79	7.05	1.792	558.	Calm. Dry Rail. Bearings cold. D. B. broke in Dyn. Car above Butler.
19	"	506.85	35	85	6	11	16.7	7.9	9.17	3.11	781.7	554.	925.6	726.1	6.00	7.25	1.960	508.	Calm. Dry Rail. Bearings warm. Could have hauled a little more.
20	"	486.20	42	74	5	11	18.0	8.9	8.09	12.44	741.6	592.5	903.3	810.7	6.06	7.30	1.538	650.	Calm. Dry Rail. All empty cars; some box, some flat.
Average.....		538.24	38 $\frac{7}{10}$	82 $\frac{3}{10}$	....	....	16.9	8.3	8.03	12.77	687.5	573.2	898.9	765.9	5.95	7.20	1.763	572.	

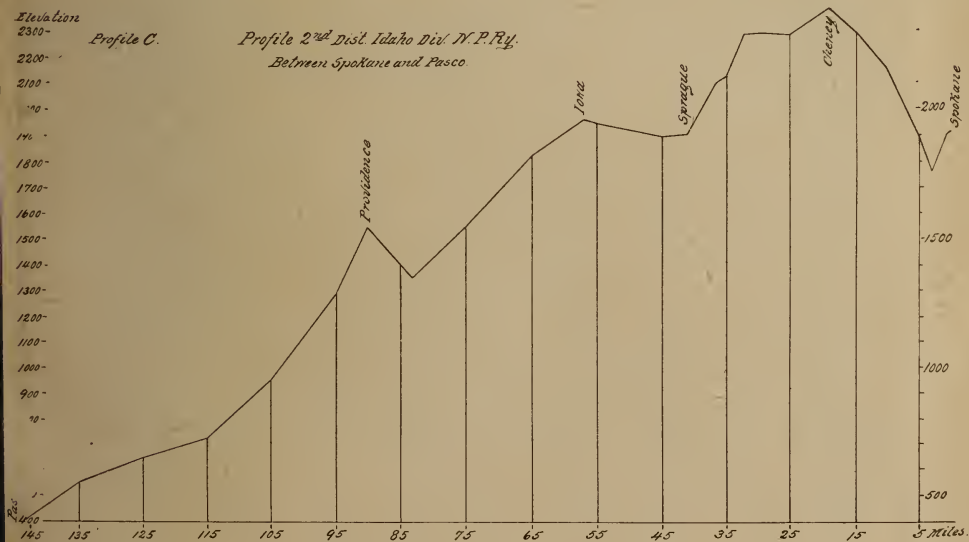
District A, on Livingston to Muir Run, is from Livingston to Mile 6.
 " B, " " " " " " Mile 6 to Muir.

District A, on Helena to Blossburg, run is from Helena to Mile 9½.
 " B, " " " " " Mile 9½ to Blossburg.

Profile B

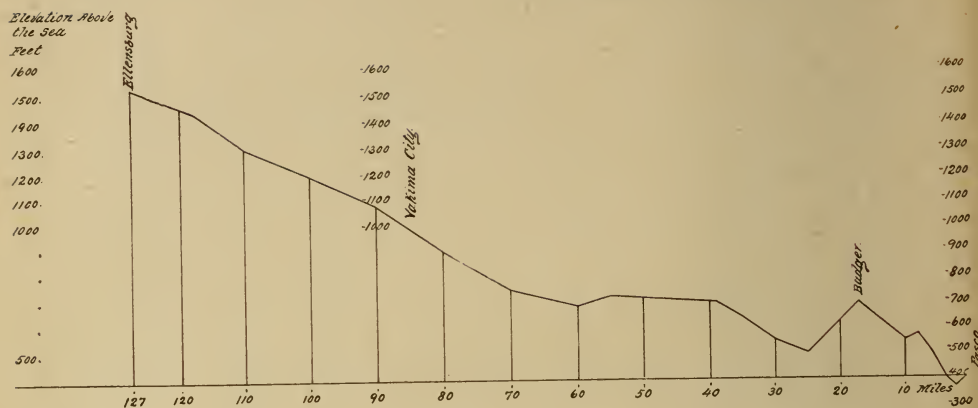
Profile of 2nd Dist. Minnesota Div. N. P. Ry.
Between Staples and Fargo

Profile C.

Profile 2nd Dist. Idaho Div. N. P. Ry.
Between Spokane and Pasco

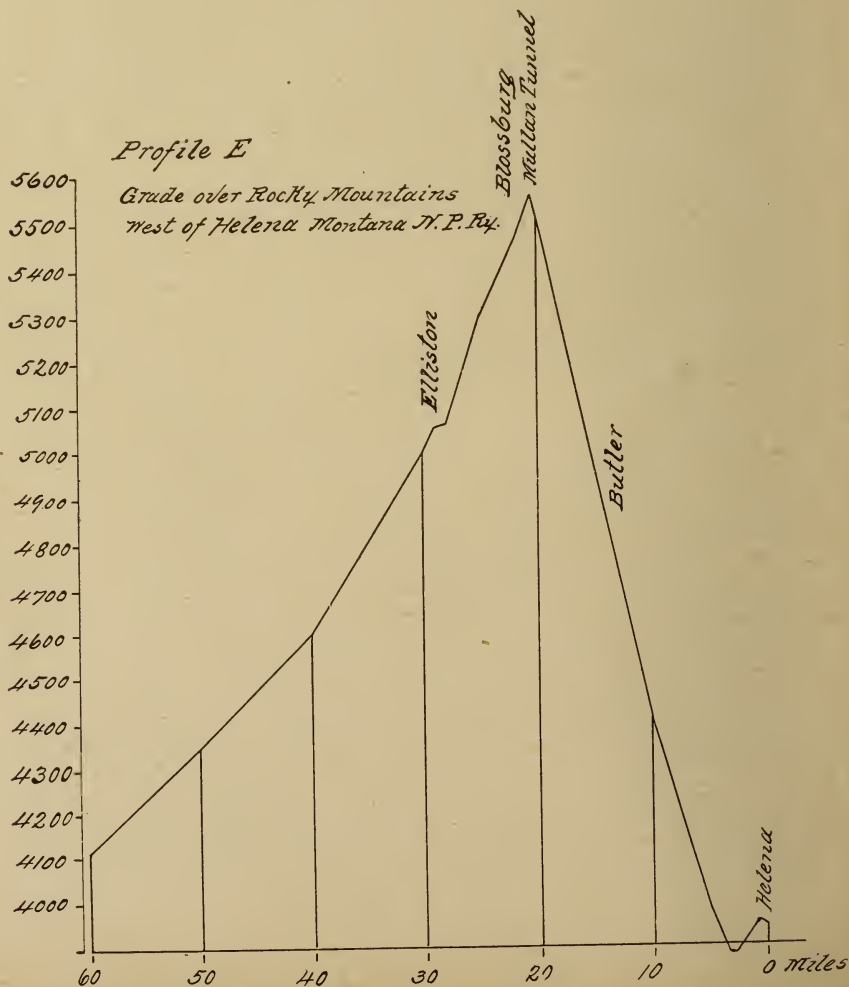
Profile D

Profile 3^d Dist. Idaho Div. N.P. Ry.
Between Pasco and Ellensburg.

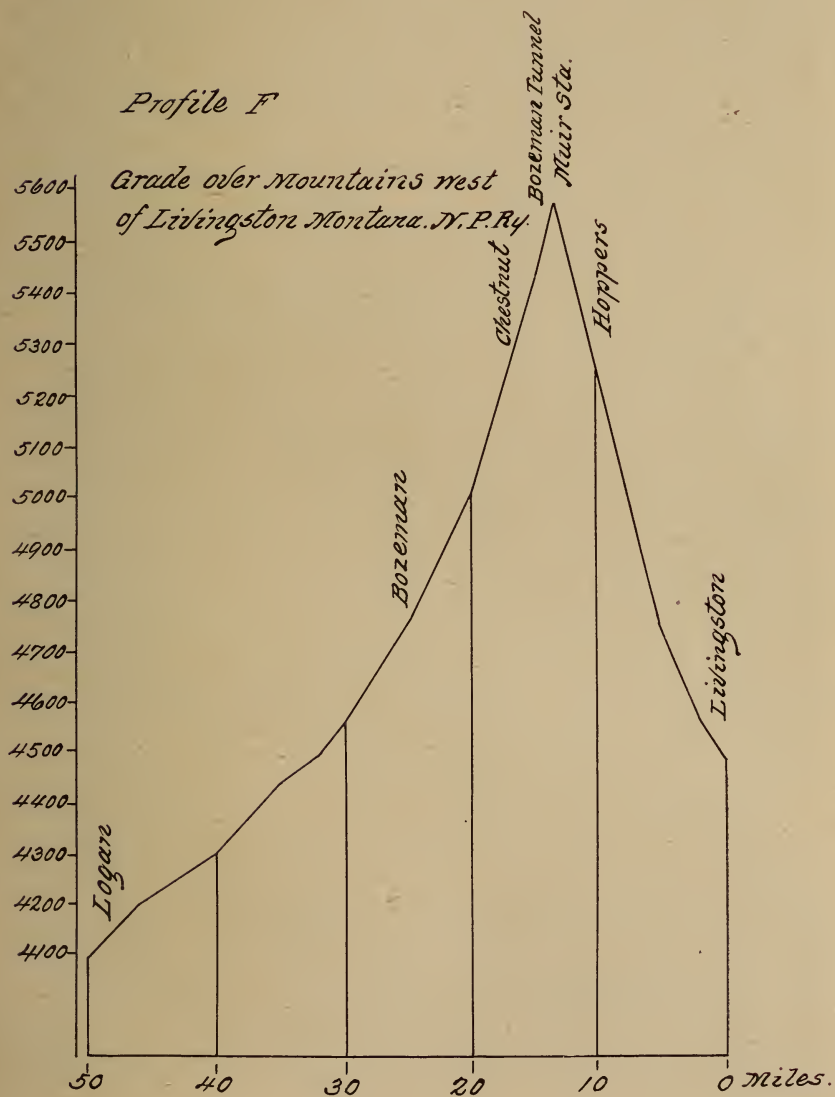


Profile E

Grade over Rocky Mountains
West of Helena Montana N.P. Ry.

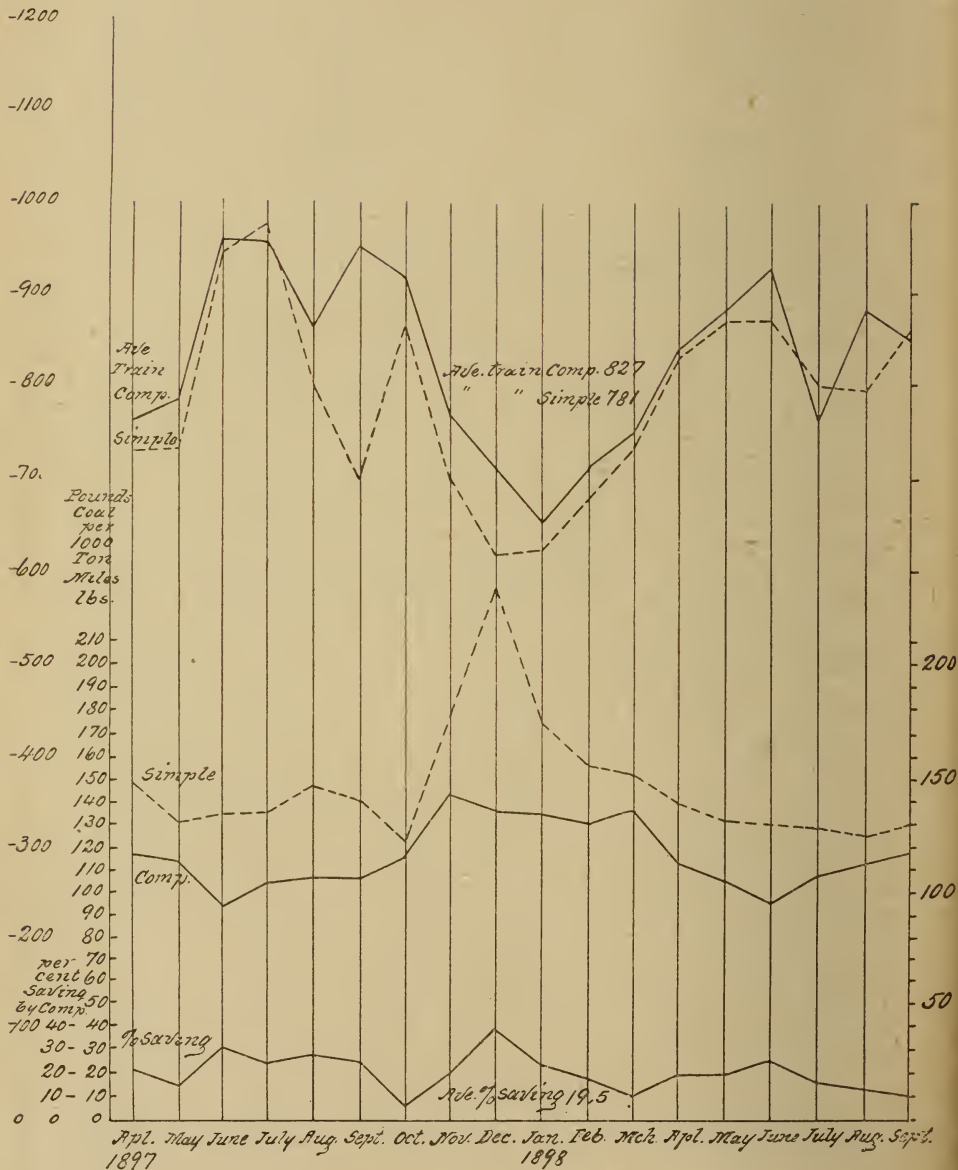


Profile F



Average
Train
Tons

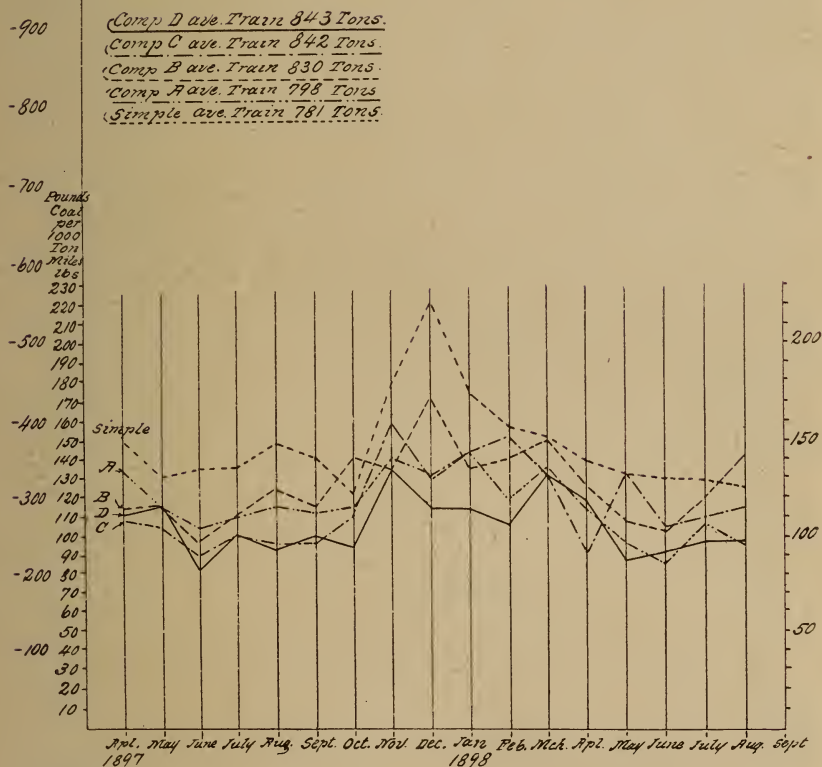
Plate A.



Performance of Class D-3 Comp. And Simple Class D-3
Loco's. on 1st Dist. Montana Div.
between Billings and Livingston

Average
Train
Tons
-1100
-1000
-900
-800
-700

Plate A1



Simple Class D-3 -----
 Comp. A -----
 " B -----
 " C -----
 " D -----

Performance of Class D-3 Comp. and Simple Class D-3
 Locomotives on 1st Dist. Montana Div.
 between Billings and Livingston.

Average
Train
Tons
-1400

Plate B

-1300

-1200

-1100

-1000

-900

-800

-700

-600 Pounds
Coal
per
1000

-500 Tons
Miles
266

-400 180

-300 170

-200 160

-100 150

0 140

100 130

200 120

300 110

400 100

500 90

600 80

700 70

800 60

900 50

1000 40

1100 30

1200 20

1300 10

1400 0

1500 0

1600 0

1700 0

1800 0

Simple D-3

Simple D-5

Comp. D-5

% D-5 Comp. over D-3 Simple

% D-5 Comp. over D-5 Simple

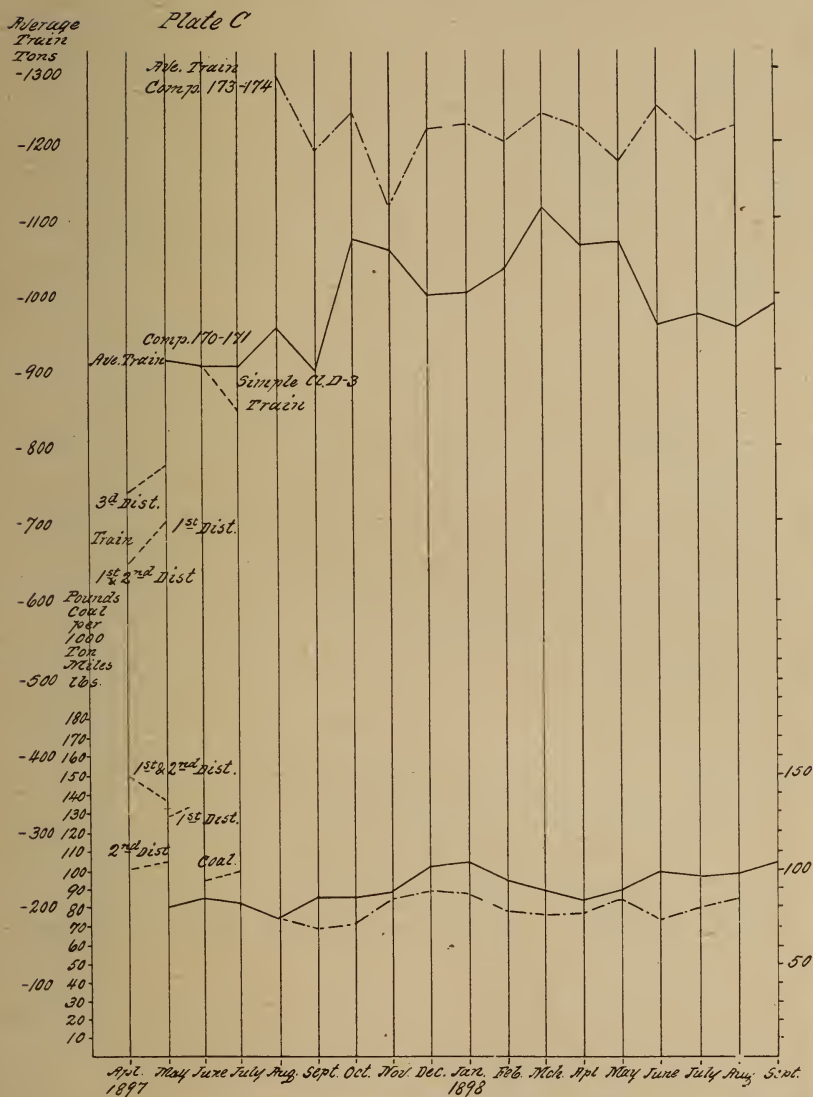
Rule every D-5 Comp. over D-5 Sim. 28.4 %

" " D-5 " " D-3 " 35.7 %

" " D-5 Simple " D-3 " 7.3 %

Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mch. Apr. May June July Aug. Sept. 1897 1898

Reg. 410 ——— Comp. Cl. D-5 Performance of Class D-5 Comp. D-5 Simple
" 430 to 432. ——— Simple Cl. D-5 and D-3 simple Locos. 2nd Dist. Minnesota Div.
" ——— " " D-3 between Staples and Fargo.



Class R Eng. — on 2nd Dist. Spokane & Pasco
 " D-3 " ——— " 1st 2nd & 3^d Dist.
 " R " ——— " 3^d Dist. bet. Pasco & Ellensburg.

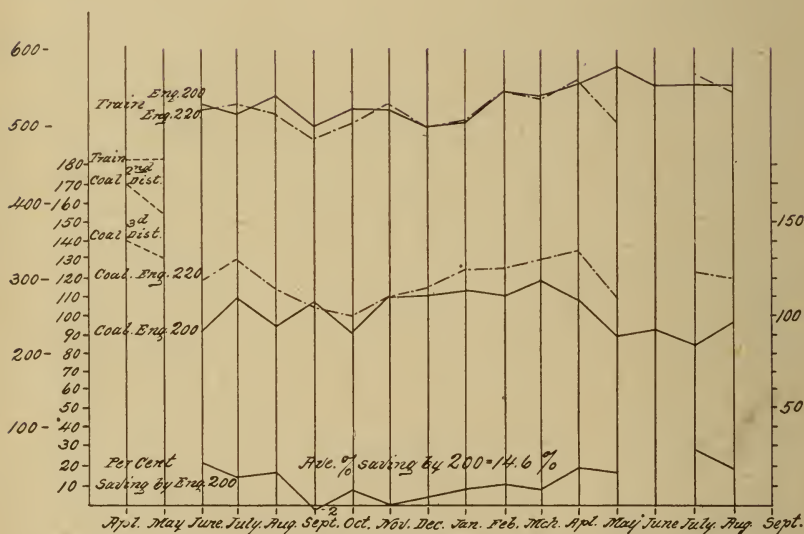
Performance of Class R Compound Locomotives on 2nd and 3^d District of the Idaho Division between Spokane and Pasco and Ellensburg.

Average
Train
Tons
800-

Plate D

Lbs. Coal
per 1000
T.M.

700-



Eng. 200 Compound
Eng. 220 Simple
Class E₂ & E₃ Eng. Simple

Performance of class P simple and compound
Locos. in passenger service 2nd and 3rd Dist.
of the Idaho Div. between Spokane and Ellensburg

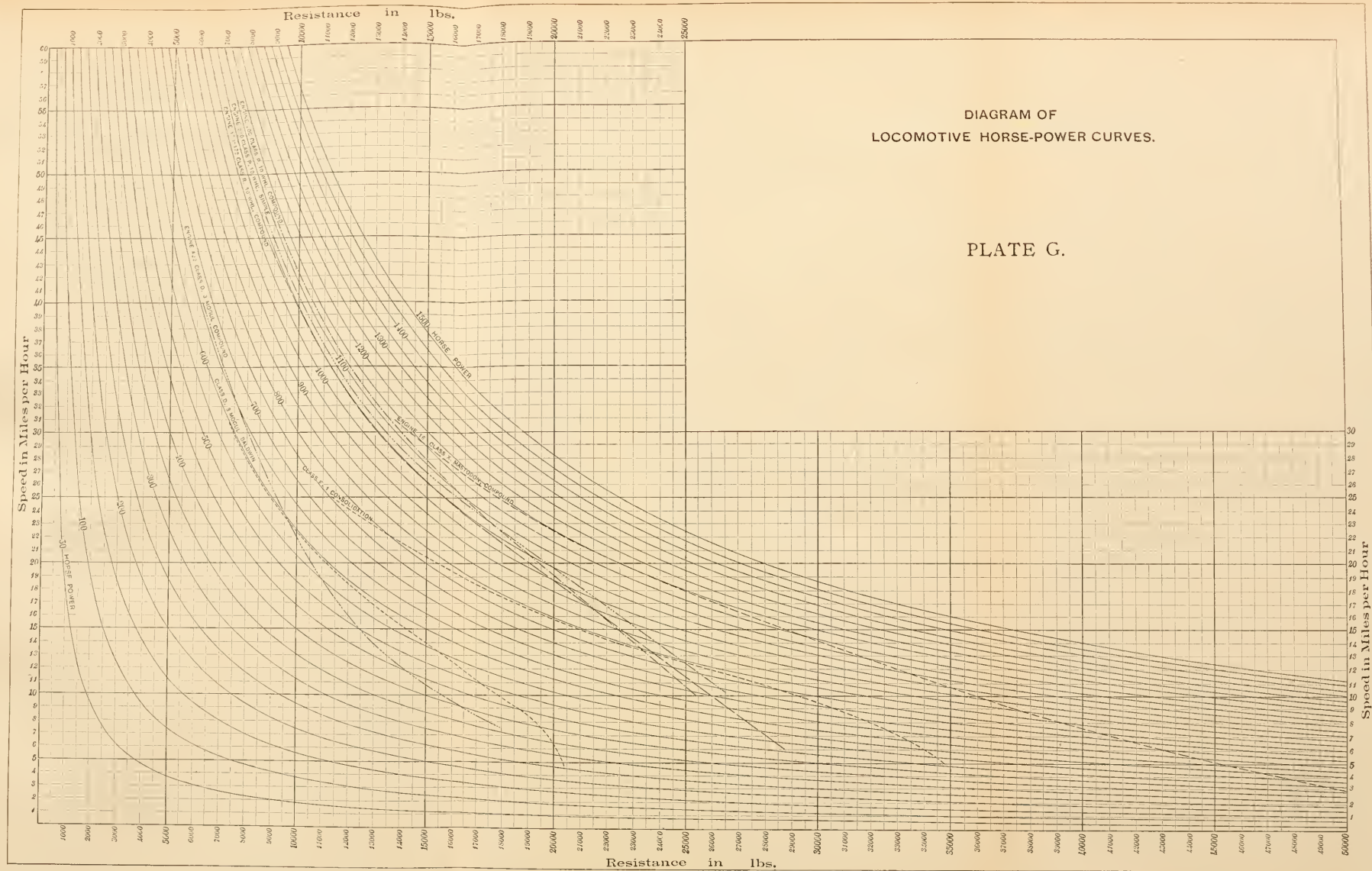
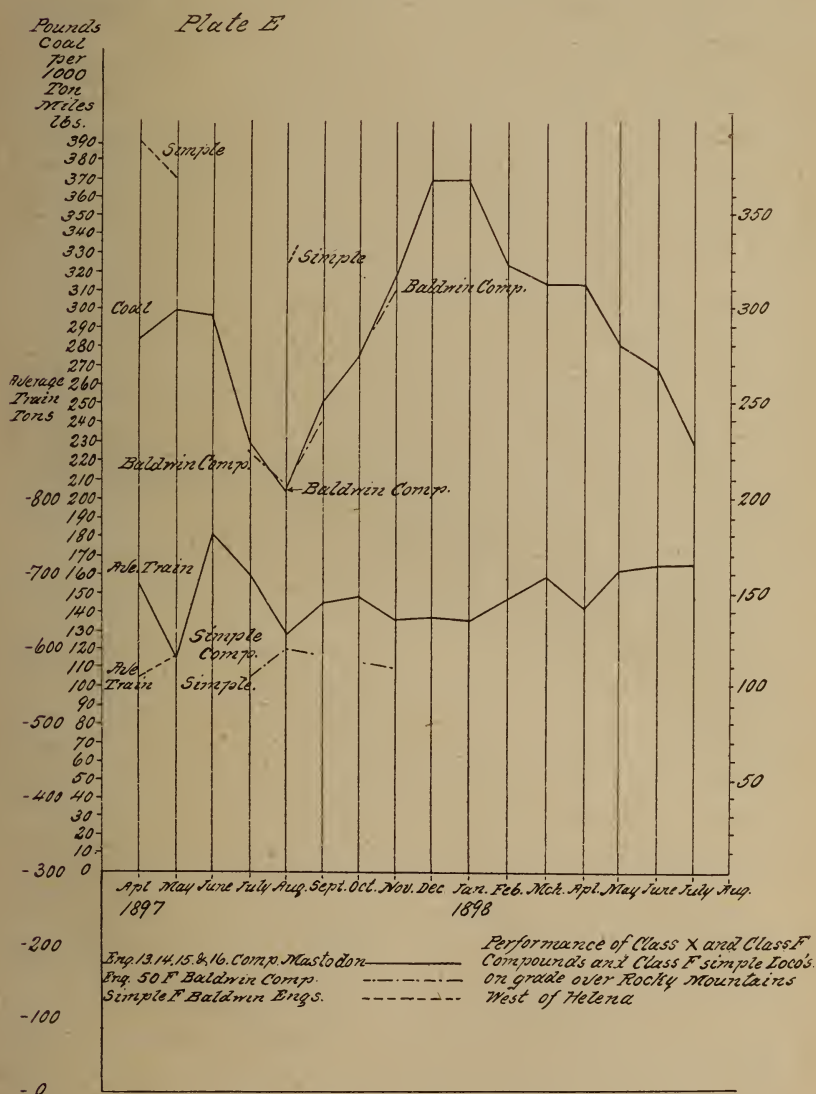


DIAGRAM OF
LOCOMOTIVE HORSE-POWER CURVES.

PLATE G.



THE PRESIDENT: Mr. Herr, it would be well to direct particular attention to the principal points in your paper, and the members will thank you to do so now, so as to call out a good discussion of the paper.

MR. E. M. HERR (WESTINGHOUSE AIR BRAKE CO.): The object of the paper, Mr. President, as stated in the last clause, is to endeavor to bring out some discussion as to the advisability or inadvisability of the use of compound locomotives in heavy freight service. From my experience on the Northern Pacific road my judgment is that it is advisable to use the compound locomotive in heavy freight service. I say advisable, because of the economy in fuel, and, as far as our experience went, no appreciable, or, at least, no important increase in the cost of repairs. It certainly seems advisable to use a machine that shows a saving of from 15 to 20 per cent. of fuel in regular service and no very great, or even appreciable increase in cost of maintenance.

The paper attempts to show the relative performance of compound locomotives under quite a variety of conditions. The Northern Pacific, as you all doubtless know, extends through a very diversified stretch of country; in the east almost a level plain; as also in certain parts of Minnesota rolling, undulating country, through Dakota and the eastern part of Montana. A continuous heavy rise in the western part of Montana, and then mountain ranges from that on until the road crosses the continental divide; and on the Pacific coast a rather exceptional condition due to the very damp weather on the Cascade Range and the heavy fall of rain and snow, making exceedingly bad rail conditions. These engines were in service on all parts of the road and in all kinds of weather conditions. As stated in the paper, the weather conditions are rather unusual, including extreme cold in the winter, especially in the eastern part.

It is also stated in the paper, and I wish to emphasize it, that the cost of repairs given are not intended to show the average cost of maintenance of these locomotives; the locomotives can not be maintained for the amount shown as cost of repairs; the repairs are merely running repairs and incident to the maintenance, and, I believe I can rightly say, the proper maintenance of the power during the first eighteen months of its existence; the engines were practically all new, the exceptions being the four compound types mentioned in the first part of the paper, which were Northern Pacific

mogul engines having the different kinds of compound cylinders placed on them. The treatment of the compounds as compared with the simples was not at all favorable to the compounds; that is, there was no "babying," as they call it, of the compounds. The master mechanics were all instructed to give the compounds the regular work, and, if anything, to favor the simple engines rather than the compounds. As this was rather a new departure to the writer, who had a limited experience with compound engines prior to going on the Northern Pacific road, I felt very doubtful whether they were just the thing to put in the regular freight service and use, on account of investigations I had made among other railroad men who had tried them and found the cost of repairs rather excessive as compared with the repairs of the simple engine. In following these engines a special point was made of investigating any difficulty that arose, either as to their operation or to their proper maintenance. If there was any trouble, and we did not get along without having trouble with the engines, it was immediately investigated and an effort made to determine what was the proper thing to do to avoid a recurrence of the same kind of trouble, and I believe that if the maintenance is followed on such a basis there should be no difficulty in maintaining a compound engine with the same regularity and a very slightly increased cost for repairs over the cost of repairs of a simple engine.

An advantage incident to the compound engine, I found, was the greater power it has as compared with the simple engine for the same weight on drivers and same cylinder power. This comes from the greater horse power capacity which the engine has, due to the fact that it uses steam more economically at the time it is taxed to the utmost; that is, when it really comes to the point where the ability of the fireman to properly maintain steam pressure and get horse power out of that engine is the limiting feature. The compound engine using steam more economically enables the fireman to shovel more horse power into that engine than he could shovel into a simple engine, consequently it can do more work. This, I believe, is shown in the diagrams, showing the average train of the compound almost universally greater than that for the corresponding simple engine. It is true the compounds generally use a higher steam pressure and this was taken into account when considering these two classes of power. This is not true, however, in the two passenger engines compared; they were exactly the same and car-

ried the same steam pressure. What is known as "Class D 3," moguls with new boilers, were almost exactly the same and with boilers designed for carrying the same steam pressure. They did not carry the same steam pressure, but that was only due to the fact that the simples seemed to do no better work with 200 pound pressure than with 180 pounds pressure; 180 pounds was all that they could stand, and consequently that was the pressure allowed. I think the economy would have been very little changed had they carried 200 pounds, so for all purposes the comparison is a strictly fair one for those two cases. This is not the case with the mountain engine; the mountain compound engines all carried the higher pressures, and I have not attempted to show the comparison except for the first one or two months as a matter of interest. It is interesting to note the relative efficiency of the 4-cylinder compounds and the 2-cylinder compounds in the mountain service. While the 4-cylinder compound showed no appreciable economy over the 2-cylinder in ordinary freight service, nevertheless in the heavy mountain service there is quite a difference in the relative performance. This is not shown on the diagram; the diagram shows that they do practically the same, but it must be remembered that the 2-cylinder compounds in mountain service had 150,000 pounds on the drivers, while the 4-cylinder had 135,000 pounds. If this difference is considered, and the relative consumption of coal is the same, I think you will all agree with me that the actual economy was in favor of the 4-cylinder compound.

I have purposely refrained from drawing many conclusions from the results obtained from this record of compound locomotives, because I hoped to have the benefit of discussion here and would be glad to answer any questions which anybody sees fit to ask with regard to the data presented, or any other facts of which I may be in possession relative to the statistics shown.

PRESIDENT SCHROYER: The Secretary is in receipt of several communications on this paper, which he will now read for the benefit of the Club.

The Secretary then read the following written discussion:

MR. W. S. MORRIS (C. & O. Ry.): Owing to the pressure of business, I am unable to be present at the Club meeting, but the subject of the performance of compound locomotives is of too great interest to me not to give a few remarks on the paper by Mr. Herr,

expressing my experience with this class of machines, and also presenting some data indicating its performance on our road.

We put the first compound engine (No. 140) on our road in 1892, on the James River division, where it has always done excellent work since, and has been running in the gang of a dozen simple engines of the same class. The compound has 19 and 29 x 24-inch cylinders and the simple engines have 19 x 24-inch cylinders; all having 57-inch driver, 160 pounds boiler pressure, and 89,000 pounds weight on drivers. The division where these machines run has little or no grades, having a length of 119 miles between Gladstone and Richmond.

Herewith, in Table No. 1, is shown the performance covering a period of five years in comparison with ten simple engines in the same class and service, and which shows a saving of 9.8 per cent. for repairs per mile, and 20.9 per cent. in fuel on the car mile basis, by the compound over the average of the ten simple engines. Special attention is invited to this case on account of the long period it covers, and the fact that the compound engine has been left exclusively without any other attention than that similar to what all of the machines in that district received.

Performance of Locomotives, C & O. Ry.

Table No. 1

Nos of Engine	Mileage			Repairs			Oil & Grease Consumed	Fuel Total	Cost per Mile Run, in cents			Cars hauled one mile			Net Cost per Ton of Lumber, per mile	No. of Ship Engine									
	Passenger	Freight	Switching	Wear & Tear	Total Miles	Labor			Materials	Fuel Cost	Oil	Repairs	Wear & Tear	Pass. Freight			Coal	Freight							
106	11336	132194	2800	90	146420	\$3550.99	1468.59	5014.38	3982.02	6901.50	21493.76	343	26	471	606	22	14.68	42236	4830262	36.5	470.05	44	178	106	
107	3145	157013	2607	100	162865	39155.93	1365.02	5280.95	4144.13	8400.52	24421.53	327	25	516	601	21	14.99	27855	5732768	36.5	456.44	42	137	107	
108	13181	120775	4879	72	138907	3011.09	1287.37	4299.46	385.68	6895.05	20570.46	3	08	28	496	623	25	14.81	47648	4102413	34.0	407.47	50	140	108
110	1909	162010	4870	392	169181	3022.74	1326.71	4334.45	424.12	8079.68	23592.71	257	25	479	615	20	13.95	6331	5923344	36.6	449.05	40	26	110	
112	30144	198657	9357	355	211383	5345.06	2069.68	7414.74	457.57	8842.02	28678.54	351	22	418	604	19	14.14	14194	7438241	37.4	569.43	40	217	112	
115	1528	153830	4527	150	160035	3644.85	1476.57	5121.42	389.49	8141.04	23724.86	320	24	509	609	20	14.82	8987	5752133	37.4	476.45	41	56	115	
118	4984	161921	3265	288	170458	2905.48	1263.53	4169.01	433.05	8739.22	24101.57	245	25	513	611	20	14.14	18488	5737237	36.7	446.86	41	222	118	
124	817	210519	3066	144	214546	5040.75	1379.46	6420.21	475.44	9690.88	30066.26	244	22	457	610	19	14.01	3629	7833458	37.2	542.32	38	144	124	
125	1626	209706	5495	742	217569	5231.32	1830.89	7062.21	449.01	8610.91	29444.79	325	21	396	605	19	13.65	6626	7826504	37.8	622.76	37	188	125	
138	8000	1446812	2720	2576	160048	3246.40	965.90	4262.30	394.98	7855.77	22620.00	266	25	449	610	22	14.13	35785	5233855	35.8	449.28	43	111	138	
Total 10 Engines	449540	1653437	43586	4849	755412	38944.61	14433.73	53398.33	4205.49	82164.59	250164.44	305	24	469	610	22	14.28	210819	60739805	36.7	449.12	41	1519		
Average						1751.41		5339.83	420.55	82164.6	25016.45													152	
140	1377	203000	6026	471	210874	4444.77	1416.70	5861.47	441.15	7831.97	27108.17	278	21	371	596	19	12.86	8365	7521006	37.0	642.49	36	153	140	
Increase						35733		521.64	20.60		2091.72														
Decrease																									
Percent						20.8%		0.9%	0.4%	0.7%	0.8%	0.2%	0.8%	12.5%	20.8%	0.2%	13.6%	20.6%	60.3%	23.8%	0.8%	2.9%	12.3%	3.7%	10.7%
						more		more	less	less	more	less	less	less	less	less	less	more	more	less	more	less	less	more	less

Being satisfied with the success of this compound, as shown in the accompanying table, we purchased, in 1895, five compound engines for our Mountain division, between Clifton Forge and Charlottesville, Va. The design of these machines being practically on the same lines as our Class G-4 simple engines, with 21x24-inch cylinders, 50-inch drivers, 160 pounds boiler pressure, and 110,600 pounds on drivers. The compound we classed G-5, with 21 and 33 x 24-inch cylinders, 50-inch drivers, 200 pounds boiler pressure, and 121,00 pounds on drivers. The performance of these engines was so satisfactory that we ordered six more for the Greenbrier district, crossing the Allegheny mountains. Some improvements were made on this lot of engines, principally by the introduction of what the builder calls an "over-pass valve," that automatically opens communication between both ends of the cylinder when the engine is running down hill, steam shut off, thus reducing the objectionable effect upon the fire by the air exhaust jet from the low pressure cylinder. We also improved somewhat on the framework and cylinder fastenings on these engines with good results.

TABLE NO. 2.

Relative Performance of Compound Engines, Class G 5, and Simple Engines, Class G 4, on the Greenbrier District of the C. & O. R'y, for Five Months ending December 31, 1897.

Kind of Engine	No. of Engine	Total miles run	Total cost of repairs	Cost per mile run in cents		Miles run to ton of coal	Cars hauled one mile		Total av. cost per loaded car per mile, in cents
				Repairs	Fuel		Av. cars per train	Av. cars per ton coal	
Comp.	340	12317	\$173.25	1.41	4.85	16.23	26.4	436.47	.55
“	341	16166	208.29	1.29	5.12	15.44	26.9	412.72	.56
“	342	17522	191.64	1.09	5.70	13.78	27.2	374.51	.56
“	343	17197	162.48	.95	5.22	15.04	27.4	410.73	.54
“	344	17856	157.32	.88	4.88	16.10	26.9	432.52	.54
Total		81058	892.98	...	...	...	...	...	....
Averages ...		.....	.....	1.12	5.15	15.34	26.9	413.39	.55
Per cent. in favor of compound			30.2%	29.2%	13%	15%	5.3%	27%	16.4%
Simp.	200	15771	326.40	2.07	5.62	13.99	25.1	329.16	.69
“	201	18787	151.25	.80	6.09	12.92	25.7	311.01	.64
“	202	16297	311.79	1.91	5.79	13.58	25.9	343.47	.65
“	206	16063	223.93	1.39	6.46	12.15	26.4	303.48	.66
“	209	15305	265.72	1.74	5.58	14.04	24.8	340.40	.65
Total		82223	1279.09	...	...	...	...	...	....
Averages ...		.....	.....	1.58	5.91	13.33	25.5	325.50	.658

Table No. 2 is an extract from the performance sheet, over a period of five months, and indicates comparison with Class G-4 engines during the same period in like service. The extremely favorable result in the repair item of the compound, may be attributed to the fact that the G-5 engines are practically new, and the G-4 being old but in good condition for their work. There is no question, in my mind, that the compound should be cheaper on repairs than the simple engine if frames, fastenings, etc., are in proper proportions, as the initial pressure is considerably lower than that of the simple engine in performing the same amount of work, or, in other words, the difference between the initial and average pressure in a compound is, under ordinary work, considerably less than that of the simple engine.

The performance of compounds justifying, we ordered twelve more engines of the G-5 class, the greater number of which are now running on the Peninsula division, between Richmond and Newport News, doing excellent work, hauling trains of 2,250 tons. During the building of these engines we changed from the car mile basis to the tonnage one; by putting the compound on the Peninsula division, where there is a ruling grade of twenty-six feet to the mile (about three miles long), we were enabled to take the same train (of 2,250 tons), delivered by the James River division, without re-arranging the train, for the whole distance of 320 miles, from Clifton Forge to the seaboard. Our aim is now to obtain a similar condition over the Allegheny, where we are introducing some mammoth engines of 186,500 pounds weight, which, for the present, we are compelled to make simple on account of lack of clearance for the required size of the low pressure cylinder in the many tunnels on this division.

With the experience gained since 1893 with the compound of the type we have had in use, and basing my conclusions upon the records made by the compound locomotives in our service, I am bound to endorse the compounding principle in freight service, and particularly so on roads where steam must be used in both directions, or the topography of the line being undulated or level.

For mountain service, however, by introducing the over-pass valves, or a device that will overcome the objectionable effect upon the fire, already referred to, the service will demonstrate greater success, and the fuel saving, though not quite as great in comparison

with the more level roads, will warrant their use within reasonable clearance limits.

PROFESSOR WM. F. M. GOSS (Purdue University): The paper by Mr. Herr is one of unusual interest. In common with all data derived from road tests, the record discloses many variables which indicate that the results, if used in making comparisons, must be subject to careful study before safe conclusions can be reached. The necessity for care in this matter is emphasized in the paper.

The fuel economy, which Mr. Herr shows to have been secured by the substitution of compound locomotives for those of simple type, confirms in a striking and most satisfactory manner the conviction of those who have hitherto given the matter careful attention. His statement concerning cost of repairs is, I think, the most complete of any that has heretofore been made. The showing also with reference to repairs is a most excellent one. Mr. Herr's plea for the exercise of patient inquiry in order that the mechanism of the compound may be perfected is altogether worthy of most careful attention. The fact is, that when a new type of simple engine is first developed, it is likely to be subject to more failures arising from minor breakdowns, than engines of a type which has been long in service. It is, therefore, inconceivable that a new type of compound locomotive should be as free from failures as an old type of simple engine. It is certainly true that engines are not to be condemned for failure of mechanism when they are successfully operated for a year and a half at a distance of a thousand miles from foundry and heavy forge shop.

The paper is a remarkably clear one, and Mr. Herr is to be congratulated upon the successful manner in which he has arranged the facts presented.

MR. ALFRED LOVELL (Northern Pacific Ry.): Since Mr. Herr has referred to my making certain tests, the results of which are introduced in his paper, I will give a few words of explanation about the tests shown by his table No. 2.

These tests were made to determine several things including possible horse power and drawbar pull at certain speeds, as shown by the steam indicator and by dynamometer car. Other determinations arrived at were the comparative fuel economy between classes F-1 and X engines when ascending mountain grades under various conditions, the maximum load of each at slow speed and also the maxi-

imum practicable speed on these grades when weight of train is equal to ten passenger cars. It will be noticed that the first two trips with each engine between Livingston and Muir were with maximum loads, and the last two in each case were lighter trains and higher speed. In order to obtain uniform conditions and eliminate any difference in rolling friction, a train of flat cars loaded with steel was used in every trip (except No. 20, Helena to Blossburg). Trains were dropped from the top of the grade and the same train used again; for the lighter trains a few rear cars were cut off. It will be noticed that engine No. 13 did not give as good average fuel economy as No. 16. This is attributive to the higher speed, especially of trip No. 12, and to the fact that this engine, No. 13, was slightly modified for experimental purposes and did not as perfectly represent the type as did engines Nos. 14 and 16. In view of the above, I believe that the result of engines Nos. 494 and 16 may fairly be compared as representing their classes under the given conditions. It will be seen that the average fuel consumption per thousand ton miles for the four trips of compound engine No. 16 is 46 per cent. less than simple engine No. 494, but if the average of the two heavy trains at slow speed of each engine are compared the fuel economy of the compound is 52 per cent. better than the simple, and if we compare the average of the two lighter trains at higher speed the percentage in favor of the compound is 38 per cent. This illustrates very forcibly the fact that the greatest advantage of the compound is derived when doing heavy work at moderate speed.

Mr. Herr suggests a comparison of these tests in up-hill work, with the ordinary performance of the same type of engines on similar grades in both directions, as shown by plate "E." On this diagram the limited number of points showing the performance of the simple locomotives indicates that the coal economy was about 37 per cent. in favor of the compound. Other comparisons of tests made on heavy grades with these types of engines indicate that this saving, under similar conditions, is not unusual. Just what proportion of this fuel saving is due to the compound feature and how much to the higher steam pressure and heavier weight of the compounds it is not easy to say, but that there is a large fuel economy from the use of compounds in service of this character when both have equal steam pressure of 175 to 200 pounds is a well established fact. Most of our comparisons between simple and compound loco-

motives have necessarily been with unequal steam pressure. The compound and simple class "P" engines referred to by Mr. Herr, however, carry equal steam pressure, and plate "D" shows that in passenger service on that division the average saving in fuel of the compound over the simple is $14\frac{6}{10}$ per cent. during a period of more than a year. I might add that the same two engines are still in the same service and had made, to February 28, respectively, 128,000 and 134,000 miles without having had any general repairs to machinery, and the ratio of fuel economy appears to be practically the same average in favor of the compound.

In addition to the saving of fuel, compound engines are a decided advantage in districts where the water supply is limited, or where the water contains alkali to such an extent as to cause foaming. Since less water is used, a longer distance can be run between supplies, enabling the poorer supplies to be omitted, less alkali and sediment will collect in the boiler and the latter can run longer without being washed out.

I have been much interested in the fuel and water economy of compound engines, and in such investigations and tests as have fallen to me to make I am free to state that I have yet to find the first case in which the introduction of the compound in heavy road service was not in the line of fuel economy. The economy in general may be said to be greatest when the work is the hardest and most constant and the speed moderate. As these conditions reverse the economy will be less, and there is a point approaching light road service and high speed, in which the economy of the compound would vanish.

The President called Mr. Peck to preside.

Mr. J. N. BARR (C., M. & St. P. Ry.): Mr. Chairman, about six years ago I was undecided concerning the economy to be realized in the use of compound locomotives. Quite a large number of people had been fooled with them and I thought that I would not use them. Now, I am finding fault with myself because I did not make use of them to a certain extent earlier. The point that Mr. Herr mentions in his paper concerning the details is quite important and has been forced on my attention in connection with compounds very strongly indeed. I believe that six or eight years ago the details of compound locomotives were not very good, not only the mechanical details, but the distribution of steam, and I think that consider-

able of the prejudice against compound locomotives on the part of pioneers in their use has arisen from difficulties in this connection. I will simply say, at the present time, that as far as our information goes concerning engines of the same type, built in every respect the same as simple engines running on the St. Paul road in general freight service side by side on the same divisions and hauling, to a large extent, the same weight of train, the compounds show about 17 per cent. in fuel economy and about 14 per cent. economy in cost of repairs. Mr. Manchester, I think, is prepared to give the figures more in detail, so that I will not dwell on them at all.

I believe that six or eight years ago the compound engine was not built so that it would show anything like these figures, certainly not on repairs, and probably not on fuel economy. I do not know. I am speaking now of the 4-cylinder compound which is rather the favorite on our road, and with which we have had altogether the most experience; our experience with 2-cylinder compounds being limited to tests of the different kinds.

There is one great point in favor of the compound over a simple engine of the same power. We hear a great deal of discussion about the limiting grades, the amount of tonnage that an engine can haul over that limiting grade, also a great deal of talk as to what will be the cost of cutting down that grade a little so that a heavier train can be hauled. Our experience and observation with the 4-cylinder compound is that, in using the high pressure steam in the low pressure cylinders, we are enabled to crawl along on a heavy grade for a considerably greater distance than would be possible with the simple engine; in other words, when the simple engine gets down to about four miles an hour, the experienced trainman will say "that is her last," when he hears a certain puff. The experienced trainman, when he first gets behind a compound engine, is fooled every time and he will say, "That is her last," a great many times. While I cannot say by how much greater load, I can say that the compound engine will get over the crest of the limiting grade with considerably more weight behind it than the simple engine can, if it comes simply to the matter of getting over. If lighter trains are hauled this, of course, does not apply; but it is a fact, and a very decided fact, and one that attracts the attention of trainmen when they first notice it most definitely. It is the heavy train, I believe, that we are figuring on to-day as affecting railroad

economy. It is the heavy train we are all after, and I am beginning to feel that we are after it a little too strongly. There is such a thing as going to the extreme, but that is not the case in a hilly division where the average train is so much lighter than the maximum weight on the limiting grade. In the latter case there is no question but what the heaviest train that can be hauled over the limiting grade is the most economical train. I question whether that is true for a strictly level road; we are not blessed with them, and I do not know much about them, but I believe that the heavy loads may be overdone under those conditions.

Mr. Herr's paper covers the ground of the discussion as to increased cost of repairs to locomotives very completely. If we look at the cost of repairs to locomotives, we will find that possibly 90 per cent. do not depend on whether the engine is simple or compound; simple or compound has nothing to do with it, and therefore we must look to the other 10 per cent. in which to find whether the simple or compound engines may affect the repairs. I have always gone along in an indefinite sort of way, thinking that if the repairs do not run up too much above the simple engine the fuel that we are saving will make the compound a good thing. I believe now that we are quite safe in saying that, under strictly similar circumstances and like construction of engines, with the use of compounds a fuel economy of at least 17 per cent. and economy in the cost of repairs of at least 14 per cent. can be depended upon.

THE CHAIRMAN: I would like to ask Mr. Barr what is the difference in the cost of giving these engines a general overhauling after they have been in service more than two years.

MR. BARR: Mr. Manchester has figures.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): That is a point which I think I will not be able to cover, but will say that I have here some statements relative to the cost of repairs. We have in our service forty-nine 4-cylinder compound locomotives. Fifteen of these are 10-wheel locomotives, weighing 89,000 pounds on the drivers; nine of them are passenger locomotives, weighing 72,000 pounds on the drivers, and twenty-five are 10-wheel locomotives, weighing 108,000 pounds on the drivers. The ones to which I will first refer for cost of repairs are 10-wheel locomotives weighing 89,000 pounds on the drivers.

The first compound locomotive received by the Chicago, Milwaukee & St. Paul railway was built in 1892, and at that time nine

Chicago Milwaukee & St Paul Railway Co.

Motive Power Department

Comparative Statement Showing Fuel Consumption, Cost of Repairs, & Mileage of 9 simple & 11 compound locos. built by the Baldwin Locomotive Works.

having same general dimensions and used in same service.

Fuel Performance for Years 1896-1897-1898.					
	Average Tons of Coal Three Years	Average Ton Miles Three Years	Lbs. of Coal per 100 tons hauled 1 mile	Cost per ton per mile	Perct. saved by Comp. engs. Compared with Simp.
9 Simple	5986.6	82442768	14.52	.001267	
11 Compound	5795.9	96838161	11.97	.001038	17.6
Performance from date built to Dec. 31 st 1898					
	Total		Average per eng. per year		Perct. decrease in cost of repairs in favor of Compounds
	Cost of Repairs	Mileage	Cost of Repairs	Average Cost per mile in Cents	
9 Simple	90187.48	2658298	1431.55	42196	3.4
11 Compound	44935.67	1695212	134961	45817	2.9
					17
					8.6
Performance for first Three Years Service					
	Total		Average per eng. per year		Perct. decrease in cost of repairs in favor of Compounds
	Cost of Repairs	Mileage	Cost of Repairs	Average Cost per mile in Cents	
9 Simple	36536.55	1128732	1353.21	41805	3.2
11 Compound	41282.30	1475320	1250.98	44706	2.8
					14.0
					6.9
Simple Engs. 818 to 826 incl. & Comp. 827 recd. Jan. 1892					
Compound " 828 to 837 " " " 1896					

January. 15. 1899.

simple locomotives of the same construction, excepting the compounding features, were purchased. Following that, fourteen other simple locomotives of the same class have been added to the equipment, but the ones that I will compare are eleven, the last four not having been in service so long, consequently will not appear in this report. The comparison is made between nine simple engines built in 1892 and one compound engine built in 1892, and ten compound engines built in 1896. The coal performance for the years 1896, 1897 and 1898, shows a saving in favor of the compound engines of 17.6 per cent. For the entire time that the nine simple engines and

*Chicago Milwaukee and St. Paul Ry.
Statement showing Fuel Performance of
14 Compound engines ($13\frac{1}{2} \times 26$) as compared
with 17 Simple engines (19×26) for 10 months
ending September 27th 1898. C & C B. III Divⁿ*

<i>Total Engine miles</i>		<i>Total Ton-miles</i>		<i>Total cost of Coal.</i>
<i>Compound 530.509</i>		<i>410.366.673</i>		<i>46.996.05</i>
<i>Simple 528.811</i>		<i>324.344.990</i>		<i>51.380.12</i>
<i>Total 1.059.320</i>		<i>734.711.663</i>		<i>98.376.17</i>
<i>Style of Engine</i>	<i>Lbs. of Coal per 100 tons hauled one mile</i>	<i>Cost per ton-mile</i>	<i>Average weight of train</i>	<i>Percent saved by Compound engines compared with Simple</i>
<i>Compound</i>	<i>13.68</i>	<i>.001145</i>	<i>773</i>	<i>27.3</i>
<i>Simple</i>	<i>18.81</i>	<i>.001584</i>	<i>613</i>	
<i>Had all engines been Compound Cost of Fuel would have been</i>		<i>Had all engines been Simple cost of Fuel would have been</i>		<i>Cost in favor of Compound engines</i>
<i>\$ 84.124.49</i>		<i>\$ 116.378.33</i>		<i>\$ 32.253.84</i>

one compound, built in 1892, and the ten compounds, built in 1896, have been in service, making three years for the ten compounds and seven years for the one compound and nine simple engines, the repair account shows a saving of 17 per cent. in favor of the compound engines and an increased mileage for the compound engines of 8.6 per cent. A comparison made with the cost of repairs for the first three years that the simple engines were in service, as compared with the first three years that the compound engines were in service, shows the saving for the compound engines in the cost of repairs of 14 per cent. and an increased mileage of 6.9 per cent. The coal performance statement, showing the actual money saved for the eleven compounds and nine simples for the entire time that all

Chicago Milwaukee and St. Paul Ry.

Comparative statement showing, Fuel consumption and percent of saving, of 11 Compound locomotives over 9 Simple locomotives for three years ending Dec. 27th 1898. All engines having same general dimensions and used in same service.

La Crosse Division

<i>Engine Miles</i>		<i>Ton-miles</i>		<i>Cost of Fuel</i>
<i>Compound</i> 1404.134		1065.219.770		\$ 110.491.48
<i>Simple</i> 988.469		741.984.911		93.993.38
<i>Total.</i> 2.392.603		1.807.204.681		\$ 204.484.86
<i>Style of Engine</i>	<i>Ibs. of Coal per 100 tons hauled one mile</i>	<i>Cost per Ton-mile</i>	<i>Average weight of Train</i>	<i>Percent saved by Compound Engs. Compared with Simple</i>
<i>Compound</i>	11.97	.001038	759	17.6
<i>Simple</i>	14.52	.001267	751	
<i>Had all engines been Compound, cost of Fuel would have been</i>		<i>Had all engines been Simple, cost of Fuel would have been</i>		<i>Cost in favor of Compound engines</i>
\$ 187.587.85		\$ 228.972.83		\$ 41.384.98

engines have been in service, shows that had all engines in this computation been compounds, the cost for coal during this time would have been \$187,587.85; had all engines been simple, the cost would have been \$228,972.83, or a saving in fuel in favor of the compound engines of \$41,384.98. We have not considered what this would amount to in repairs, as I think that we do not take the position that we expect to get any better showing for repairs from the compound engines than we did from the simple engines.

We have twenty-five engines of the heavier class weighing 108,000 pounds on the drivers that were run in competition, or in comparison, with what we call our 19 x 26-inch simple engine, carrying 150 pounds pressure of steam. The saving in coal on this class

of engines was 27.3 per cent., but you will note that the last twenty-five engines referred to are more powerful, by about 25 per cent., than the engines with which the comparison is made. The service in which the freight engines are, fifteen on the La Crosse division, between Milwaukee and La Crosse, and twenty-five on the C. & C B. division, between Chicago and Savanna, is rather a fast freight service. Out of 135 consecutive trains covering a period of several days, the average time in making the run, from leaving time to arriving time, was eighteen miles per hour for the slowest runs and twenty-four miles per hour for the fastest runs. It is a service in which from 45 to 50 per cent. is fast stock, meat and fruit service in one direction and merchandise in the other.

Referring to the locomotives in passenger service: We have never regularly installed the tonnage system of reporting the coal consumption or performance of engine in passenger service. The compound engines are handling all heavy trains and the simple engines were handling as heavy trains as they were capable of handling, but not nearly as heavy in tonnage as the trains hauled by the compound locomotives, so a comparison was made to determine what the relative values of the simple and compound engines were in passenger service on the tonnage basis. The simple engines have 18 x 24-inch cylinders and carry 160 pounds of steam, and have 68-inch driving wheels. The compound engines are 13 and 22 x 26-inch cylinders, carrying 200 pounds pressure of steam and have 78-inch driving wheels. Made up on a tonnage basis, it was found that the compound engines hauled a 100-ton passenger train at a cost of a little more than nineteen pounds of coal per mile. The simple engines running on the same division, but hauling lighter trains, yet hauling just as heavy trains as they were capable of hauling, cost thirty-one pounds of coal to haul 100 tons of train one mile. The transportation department is generally a pretty good thermometer from which to judge the general desirability of an engine in train service, and I may say that our transportation department is well pleased with the compound locomotives. The officers of this department say that when they get a compound engine on the train they know it is not going to get stalled on the hills, and if they want an exceptionally fast run made they can depend on the compound engine making the run.

In conversation this morning with a representative of locomotive

builders on the subject of the paper, I suggested that if those who build new types of engines would send a competent representative to watch and keep track of what is going on with the new type of engine and keep the builders fully advised of every occurrence which shows a weakness or a lack of proper construction, better results would be obtained.

The Chairman asked a question about the cost for general repairs: There are some parts of the 4-cylinder compound locomotive which are expensive to maintain, not so much in general repairs, but in constant repairs, and these are the cross-heads and guides. These must be followed closely and taken care of all the time, but there is a compensating decrease in the cost of maintaining the piston valve. I must say that I have been surprised to find how little attention the piston valve requires and how cheap are the repairs. In case of a wreck, if it happens that a pair of compound cylinders are knocked off it will be found that the repairs will be costly. We put a pair of simple cylinders onto an engine at a cost of about \$300; if a pair of compound cylinders is required you may multiply that by three, and, possibly, add something more to the product. We are making simple cylinders under approved methods; we have our tools in shape and everything in proper condition to make such cylinders cheaply; when we are equipped in the same way for the compound engine, I believe that we will be able to reduce this price that I have given, by one-half, but at present, unless other people are fixed differently from what we are, they will find that their tools are all too small, the lathes do not swing and the planers will not carry the cylinders, and, in fact, the castings are too large for the tools now in general use. We find the castings not only too large for the tools, but also that they have too much spread for the roundhouses and the locomotives are too heavy for the turntables.

THE CHAIRMAN: Mr. Marshall, have the North-Western any figures on compounds?

MR. W. H. MARSHALL (C. & N.-W. Ry): The North-Western has no modern compounds, excepting possibly one, the Richmond. We have altogether five, one Schenectady, one Richmond and three Baldwins, and they are all comparatively old engines and they all show some of the defects in designs common to the first compounds that were built, namely, that the cylinders are too small to do the

work done by engines with simple cylinders with which the compounds have been rated, and we have found that, to some extent at least, this over rating of the compounds has reacted against them. Two of the five cannot haul trains equal in weight to those hauled by the simple engines with which they are competing; in spite of that, however, they do show an economy over the simple engines. The records show a saving of about 12 per cent. in fuel and, I think, the repairs were about equal in cost to the repairs of the simple engine. The compounds are all running in comparatively fast service, perhaps faster than that for which they were designed, and if they had been in slower service they undoubtedly would have shown up much better. We hope, however, that the North-Western will soon have more modern compound engines on which to base some figures.

I will say in relation to the difficulty with the cross-head of the 4-cylinder compound, of which Mr. Manchester spoke, that we had so much trouble with the cross-heads of one of these locomotives that we threw away the cross-heads and the guides and built a new set, just doubling the width of the guides, making them five inches wide, and, furthermore, cut out the bearing surface in the middle of the cross-heads. That engine has been running about five months without having any work done on the cross-heads, something quite impossible before. In looking over this paper it seemed to me that for those who desire to try compounds some of the most valuable data given is that showing that it is possible to get as much mileage out of the compound engines as out of the simple engines, and that the running repairs are not going to be any greater, at most, than the corresponding repairs on simple engines. With these two facts in mind, it seems to me that there can be no doubt as to what course to pursue. If the running repairs will not be any greater and if it is possible to get as much mileage out of the compounds as out of the simple engines, the fuel saving will far more than offset any increase in the cost of general repairs. In fact, if a large engine hauling trains averaging a thousand tons and running 100,000 miles between general repairs, with a saving of, say, 15 per cent. of the fuel, if coal is about \$1.50 per ton, it will be found that the saving in running the compound will pay for the entire cost of repairs no matter how excessive that may be.

MR. BARR : I would like to say one word that I neglected to

say before. There seems to be a kind of doubting hesitation to the use of compound locomotives as to their adaptability for making fast runs; I see this tendency prevailing all the time. It has become almost a dogma that a compound engine is a good engine for a slow run and a heavy pull. I am almost prepared to take the position that the compound engine is the very best engine for fast runs, better than it is for slow runs. If there is any difference, the difference is in favor of the compound engines. Every one knows that the fuel consumption runs up enormously with the increase in speed, the horse-power does, and that means fuel consumption. There are hundreds of diagrams showing this. We all know, too, that for a certain horse-power there is evaporated from 15 to 20 per cent. less water for the compound engine than for the simple engine and a corresponding amount of fuel, so that, within the same limits, I am decidedly of the opinion that the compound engine is better adapted to fast running than is the simple engine. In addition, with the 4-cylinder compound, in which the guides and cross-heads seem to play such an important part, the difficulties with them in fast service are very much less than they are in slow service. It is the slow, heavy pull that brings the twist on the cross-head, that makes the guides quiver; but with a very fast running engine I am inclined to think that the trouble, if such there is with the 4-cylinder compound, will be very little increased over that of the simple engine, and I intend, when I get back, to make some observations on the cost of repairs to guides and cross-heads of the freight engines and the fast passenger engines. I do not have the figures now, but I do not know of any reason for the assertion that is made, and made until we all feel like believing it, that the compound engine is not very well adapted to a fast service. I believe it is a mistaken idea.

MR. R. H. SOULE (Baldwin Locomotive Works): I am at a disadvantage in this matter, owing to the fact that I have not read the paper. I found it on my desk on my return this morning, and my only knowledge of this paper is what I have gathered from the discussion as far as it has proceeded. I think that a very good point is made in the paper as alluded to by Professor Goss, and still later by others, that some allowance ought to be made for the fact that the compound engine is of more recent date than the simple engine; the fact being that all our mechanical talent has been con-

centrated on the perfection of the simple locomotive for about sixty years, whereas a portion of that talent, only, has succeeded in bringing the compound locomotive to a moderate degree of perfection in eight years. I am not so familiar with the date when 2-cylinder compounds were introduced in this country, but it was in 1891 that the Baldwin Locomotive Works got out their 10-wheel, 4-cylinder compound engine No. 82, and offered it to our railroads for service trials. I think that was practically the beginning of their business in the making of 4-cylinder compound engines, which has since grown to considerable proportions. In addition to that handicap we have the other serious handicap that the compound locomotive, from the nature of the thing, never can be so simple as the simple engine, under any circumstances. I think it is also true, in the case of the 4-cylinder compound at all events, that it was, perhaps, rushed onto the market a little too soon, and crowded onto the railroad people a little too hard, before we found out all these things that we know now, and which we have learned from experience in actual service.

In thinking of the development of the 4-cylinder compound, different things have occurred to me, which show the increased advantages which have been obtained in the construction of 4-cylinder compound engines since 1891. For instance, the cylinders are made larger now than they were before; that is, in designing compound cylinders to replace simple cylinders, we would to-day make the compound cylinders larger in diameter than we formerly did. In addition to that, the ratio between the volume of the high pressure cylinder and the volume of the low pressure cylinder is different now from what it was at first; I do not carry in my mind the exact figures of the ratio, but I know they are different from what they were at first. Then, again, valves and valve chambers were not made large enough at the beginning; they are made from an inch to an inch and a half larger in diameter now than they were at the beginning; the area of the port openings is correspondingly greater; the steam passages are differently arranged; the arrangement of lap and lead, and, in fact, the whole construction of the valve is different from what it was then. There was one great trouble in the early compounds which ought to have been anticipated, but which was not. When a 4-cylinder compound is drifting down grade, we must not only relieve the vacuum which forms back of the high

pressure piston, but there is still a more serious vacuum developed, owing to the difference in the volumes swept by the high pressure piston and the low pressure piston at a time when the two cylinders are in communication. Modern 4-cylinder compounds drift freely, proper relief valves being provided. Then the contention was made at the outset that the 4-cylinder compound might be so designed that under ordinary working conditions the loads on the high pressure and low pressure pistons would practically be the same, so that there would be no rotative effect on the cross-head; but I do not think that the makers and advocates of the 4-cylinder compound are inclined to press that claim any longer; in fact, it is pretty thoroughly understood now that there is only one position of the reverse lever for any given set of conditions, such as steam pressure, speed, etc., where that can be true; if that one position is departed from by throwing the reverse lever either forward or back, that equality of loads on the two pistons is destroyed. On account of not realizing that condition of things the guides of the original 4-cylinder compound engines were made altogether wrong; they were made on the same basis as had been found to be good practice in the simple engine. In the 4-cylinder compounds to-day the guides are more than twice as wide as they were on the original engines. Two and a quarter inches was the original standard, now it is five inches. Besides this, the guide yoke is made heavier and stronger than originally, and is more firmly attached to the boiler.

Mr. Herr's paper, I believe, dwelt more particularly on the economy of the compound engines in freight service, but the discussion has also taken in the results that have been reached in passenger service; and I may say that some of the most successful achievements in recent 4-cylinder compound engine practice have been in the line of fast and heavy passenger service. The success in that line seems to be due to several different things. One element, of course, is the general improvement of the engine and the fact that the distribution of steam is better understood. Another, is the fact that the engine is perfectly balanced as between its two sides; that is not true of the 2-cylinder compound. Besides this, I am told that one of the difficulties experienced in running a 2-cylinder compound at high speed is that, on account of the complication of the intercepting valve, the back pressure runs up very rapidly in the high pressure cylinder; but in the 4-cylinder compound, where there is no intercepting valve,

there is no trouble of that sort ; therefore I think that any review of 4-cylinder compound engine practice of to-day is not complete without referring to the fact that we have reached very good results in high-speed passenger service.

PROF. L. P. BRECKENRIDGE (University of Illinois): I did not come prepared to say anything on the paper. I was much interested in it and have been interested in the remarks. The thought comes to me, in connection with some of the remarks along this line, that we frequently make the statement that it is hardly fair to compare the simple engine with the compound, because the compound has higher boiler pressure. It seems to me that if we did not have the higher boiler pressure, we would not think of using the compound. The economy in the engine is insured by compounding, as the boiler pressure increases; this is accountable in the same way for the increased efficiency of locomotives that have been compounded. The efficiency has been increased because we have been able to give the compound engine a higher steam pressure to work with, and while it is true that it is not possible for the compound locomotive to compete with the compound stationary engine on account of the variation in the load to which the locomotive must necessarily be subjected, there is still a chance for the compound to occupy its place as a compound, comparably with the stationary, in the same way that the simple locomotive occupies a certain position and gives a certain economy which is comparable with the simple stationary engine.

MR. J. F. DEEMS (C., B. & Q. R. R.): I have not had sufficient experience to say anything about the work of the compound locomotive, but one thing has impressed me here, and in fact has impressed me in almost every conversation I have had since we began using compound locomotives, and that is the point referred to by Mr. Herr and Mr. Soule. It seems astonishing that we should expect the compound to be a success from the start when, for years and years, we have not been able to turn out a new type of simple engine that was a success from the start.

PROF. R. A. SMART (Purdue University): I think the Club is to be congratulated on the data which has been set forth in this paper, because it is a matter of considerable difficulty to secure accurate data in road service, where there are necessarily a great many variable elements entering into the performance of the

engines. There is perhaps no other road which could have given us such a variety of types and variety of service as that from which the data has been presented to-day. The discussion has already brought out the fact that many variable elements are involved in the information which this paper presents. The author of the paper has carefully called attention to these variables, and has stated that they should be taken into account before any accurate comparisons can be made from the paper. This is, unfortunately, a thing which too many authors fail to do.

There is one point which occurred to me as I was looking over the paper and it may perhaps have occurred to some others. It is in regard to the meaning of the last diagram, the diagram showing curves of locomotive horse-power. When first looking it over, I misread the diagram, supposing it to represent maximum cylinder horse-powers, or, in other words, cylinder capacity. I was naturally surprised to find that the horse-power of the cylinders was practically a constant quantity with increase of speed, a thing which would be rather surprising if true. After studying the curves more carefully, I found that they do not represent cylinder capacity but rather boiler capacity; that is, they represent the maximum power of the machine considered as a whole, and not that of the engines alone. Attention has been called many times to the fact that the real limit of the locomotive is the limit of its boiler, and not the limit of its cylinders. In other words, the cylinders will always take care of all the steam which the boiler can supply to them; the boiler will fail under extreme conditions to furnish enough steam to the cylinders.

I noticed that, at the lower speeds, these horse power curves fall below the hyperbolic curves representing constant power, and was at a loss to understand why that should be; why the boiler should not be as efficient at the lower speeds as at the higher speeds, but in conversation with the author of the paper he told me that the reason was that, at the lower speed, the limit of traction was reached and trouble was experienced with slipping. I think that these points are worth calling attention to in considering these very interesting curves.

MR. GEORGE W. CUSHING (Mechanical Engineer): The paper presented by Mr. Herr is most interesting. To the writer, whose opportunities to observe progress in these matters are fairly good, it

would seem that the development of the compound locomotive has reached a point in economical operation and superior horse power efficiency which places it in advance of anything possible to be reached by the simple engine; reference is made, of course, to locomotives now made, not those experimental ones of years ago.

As *types of the locomotive*, why should not the simple and the compound be estimated, as are stationary and marine engines, each at its best point of efficiency, and not, as is usually stated, at equal steam pressures? It is established that the simple locomotive is most economical at pressures below 190 pounds, while the compound, intelligently placed and handled, is best at a pressure above 190 pounds, the higher the better, within present practicable limits. The discussion on Mr. Herr's paper has brought out a remark by one of the speakers that it may be proper to notice because of its *originality* and *evident meaning*, which remark was to the effect that builders of special types of engines, like the compound, would find it to their advantage to adopt and follow the system of looking after and following the details of its business on railroads. This is possibly intended as a hint to builders of locomotives that their product would generally be more to their (the builders') satisfaction, or credit, through the adoption of such a system. Circumstances, however, may be very much different in different cases; for instance: The locomotive builders' product is sold outright, and remains permanently with the purchaser, developing good or poor results, as the case may be, for many years, while the maker in the original deal has received his profit. The railway official considers that, after he gets possession, the locomotive is entirely under his charge to use as the interest of the employer, in his judgment, requires. Another company, to which the remark might refer, enters into an agreement, as a rule, to reach results in the use of its product, and upon the fulfillment of this agreement hinges, in part, the compensation. If a similar system, as suggested, should be put in use between locomotive builders and the roads, builders would necessarily share in the responsibility of operating, and in the saving in cost per ton mile, etc. It might be entirely safe for enterprising builders, or others, to undertake to re-stock railroads with new power, receiving in payment an agreed percentage of the saving in operating per ton-mile for an agreed period of time, but this would, of course, in the case of locomotives, necessitate a share also, by the builders,

in the control, operation, repair and care of the same. It certainly presents an interesting subject for consideration, and possibly this may be what the gentleman intended.

Mr. Herr's paper, and his remarks in the general discussion following, indicate his idea of the probable limitations in the use of the compound locomotive, which limitations, of course, must be judged intelligently in each instance; we may have in mind, however, that while the compound is *now at the front* by reason of its improvements *during the past few years*, it may be yet further improved to fit it for use as an "all-round" engine. In the meantime, however, much may be accomplished, in re-stocking old roads with new power, by a careful consideration of existing conditions and locomotives, and the replacement of these, when necessary, by others better suited to the ends desired; in this case the compound must hereafter be taken into consideration as a factor.

MR. E. E. RUSSELL TRATMAN (*Engineering News*): I have been particularly struck by Mr. Barr's reference to the use of compound locomotives in high-speed service. There is, it is true, a certain general impression that the compound system is more particularly adapted to slow, heavy freight service, but the fact that compounds are in use for the Philadelphia and Atlantic City and the Philadelphia and New York express trains of the Philadelphia & Reading R. R., and the Central R. R., of New Jersey, seems to show pretty clearly that the engines are adapted to the fastest passenger service. The Atlantic City express trains are handled by 4-cylinder compounds of the Atlantic type, with about 76,500 pounds on the 7-foot drivers. The cylinders are 13 x 26 and 22 x 26-inch. The train load is from five to seven cars, or about 260 tons, and the run of 55½ miles is made daily (during the summer) in fifty minutes, or at an average speed of 62.2 miles per hour for 55½ miles without a stop. The actual running speed is from 60 to 84 miles per hour. Other roads are using compound locomotives in somewhat similar service, and I think it would be of interest if we could get some particulars of the comparative performance of compound and simple engines in fast passenger service under the same conditions, in the same way that Mr. Herr has given the comparative performance in freight service.

MR. MANCHESTER: I will tell you what I know of the single driver engine, (it is not very much). The fastest ride I ever took was

on a single-driver engine. Going out of New York the engineer said: "When we pass Elizabethport I will give you a ride." The card time of the train we were on called for twenty-three miles in twenty-two minutes; after jogging along at a pretty lively rate for a little while I saw the engineer shutting off steam and applying the air and I looked for a place to jump, but he said: "Do not be scared; I am three minutes ahead of time, and I cannot pass Trenton Junction ahead of time." That was a compound locomotive.

MR. C. B. CONGER (*Locomotive Engineering*): In my travels around the country I find that whenever the cross-heads and guides of the 4-cylinder compound are not properly taken care of and kept in order, not exactly daily, but weekly, the enginemen say that the compounds are "no good"; but whenever I find these parts in good order, the enginemen say the compounds are better than the simple, so I think that a great deal of the prejudice against the compound has been due to the fact that the men in charge of repairs have allowed the cross-heads to get out of order. I was in one railroad yard when a compound was going down through the yard with a full train at full speed, and the cross-heads were making a great deal more noise and pounding more than ordinary driving boxes do when they get out of order. Every engineer on that road whom I asked about the compound said he did not think they amounted to anything, they could not do as well as the simple engine, and were always breaking down. I was at another place where the locomotives were well taken care of, nineteen of them, and there they think the compound engines are the only good ones in use. I rode over the Lehigh Valley road, on a Columbia type, "Mother Hubbard" as they call them, that made eighty-five miles an hour, and we made a good many miles in forty-three seconds and some miles in less time.

MR. H. H. VAUGHN (Q. & C. Co.): I have ridden on the single-driver locomotive of the P. & R. a number of times, but as far as speed is concerned, of course there is no more speed in a single-driver than there is in the coupled engine with the same diameter drivers. I have not ridden over eighty miles an hour on either of the single-driver engines there, and as compounds they have the great objection that there is the most excessive overbalance, or counterbalance, in the drivers. In fact, there is about 700 or 800 pounds over and above the rotating weight to counterbalance, in order to make them run anything like steady. Those locomotives

tives running at high speed on a bridge make the bridge dance pretty well under them.

In reference to what Mr. Barr said about the economy of the compound at high speed, I think most decidedly that the compound shows better at high speed than it does at slow speed. I have watched the cross-heads a great deal on such engines, and they show very little wear, whereas everybody well knows that in very heavy freight service the cross-head will cut loose in a few trips, that is, where there is much steam used on the low pressure cylinder. The Reading, of course, has a lot of the earlier compounds, and the troubles encountered there are really those due to the extra strains that arise from compounding, not being properly taken care of. We had a great deal of trouble with broken frames and that, perhaps, was our own fault, as on that road there was a great deal of water worked in the low pressure cylinder, and that will cause trouble with a compound locomotive about as quickly as anything. We had considerable trouble in preventing the men from working high pressure in the low pressure cylinders, so much so that we had to put a lock on the lever to prevent them from so using it when the lever was hooked up out of the corner.

On repairs, I am sorry to say I have no figures to give, as the repairs were not classified according to classes of engines. But with the older type of compounds we had considerable repairs to make. The load on the drivers was about 130,000 pounds, and yet month in and month out these heavy locomotives pulled very little more freight than a lighter and simple engine would have done, and there were annoying little repairs every time the engine came to the roundhouse that with the later compounds we did not find.

MR. MARSHALL: I believe that a modern compound engine will show economy at high speed, and what I said about compound engines at slow speed showing up better than at high speed is true, because they were the older type and I believe were not fair examples of high speed modern engines. Mr. Soule spoke about the better patterns, and that all the earlier compounds suffered at high speed from defects in construction. I believe that is where all the prejudice against high speed compound engines has come from, and I expect that after we have had the modern compound engines on our system, we will have no difficulty.

MR. DEEMS: It seems to me this is one of the most valuable

papers that has come before the Club since I have been a member, and it also occurs to me that it is one of the most important subjects, just at this time, that can possibly come before the railroads, and I wondered if it would be advisable to appoint a committee to collect data from service tests, the same to be put together for comparison. The data would be very valuable, and it would be consistent for this Club to attempt something of this kind.

MR. CLEMENT F. STREET (Dayton Malleable Iron Co.): There is one point which I think has not been touched on, namely, the adaptability of the compound to varying loads. I think it is quite reasonable to suppose that the majority of the compounds on the St. Paul, from which the record is given, are loaded to their full capacity. I should like to know whether any of the gentlemen have figures bearing on the service of the compound in comparison with the simple, where on one trip the locomotive takes out a half load and on the next trip a full load. I do not suppose that there is very much service of that kind at the present time.

MR. BARR: Mr. Chairman, I think Mr. Street is ten years behind the times. It is not a question now whether we have got to adapt an engine to haul half a load; it is a question of how we are going to adapt the engine to pull another car more than it does haul at present.

MR. STREET: I guarded myself on that point when I said I thought that there was not much service of that kind at the present time, but I was asking for information.

MR. MANCHESTER: I think that Mr. Barr did not answer that question just right. The trouble with us is to get cars enough to fill out all our trains to the full rating of the locomotives. The twenty-five locomotives that are running between Chicago and Savanna on our Council Bluffs division are rated at 1,200 tons hauling capacity. The average train that those engines haul is 750 tons in weight. I have here a list of 135 trains, and I find that two of them were of 600 tons hauled by engines capable of hauling 1,200 tons; of course the engine is considered a part of the load. Eleven of the trains weighed 700 tons; eighteen of them, 800 tons; five of them, 900 tons; three of them, 1,000 tons. The fuel record I gave was based on those conditions of train loads.

THE CHAIRMAN: You might run smaller engines and save more fuel.

MR. L. R. POMEROY (Cambria Steel Co.): Before Mr. Herr closes his remarks and at the risk of exposing my ignorance, I would like to ask one or two questions. It is my belief, that, as a general principle, the compound locomotive is a more economical machine than the simple locomotive. But is there any one field more than another where this economy is manifest, or if flexibility is desired in an engine, is the compound as flexible a machine as the simple type of engine?

Also the question of ratios of high and low pressure cylinders; should not this ratio vary with the class of service? I understand that on the Northern Pacific road they have experimented with engines with different ratios of cylinders, and I would like to know what this experience has shown as to the adaptability of certain ratios for mountain work, or whether different ratios were to be used for the level and fast passenger work. Of course, we understand that, to a certain extent, the simple locomotive is modified and designed to meet special conditions, but in the compound as to the question of ratio of the cylinders, does this ratio affect in any way the adaptability of the engine for both level and mountain work?

MR. ROBERT MILLER (Mich. Cent. Ry.): We have no modern compound locomotives, but I think that we were very well to the front of the procession in the introduction of the compound locomotive. I think we have on the Michigan Central the first one of the type built by the Schenectady Locomotive Works. Our compounds are not modern. The remarks of Mr. Marshall would apply to our engines. Notwithstanding this, however, a careful comparison of four months with the same type of simple engine over the same territory and hauling the same tonnage, shows an economy of at least 15 per cent. in fuel. While I cannot give any figures for the cost of repairs, I think that the cost is no greater than for the simple engine. We had two of these engines, one on the Canada division and one on the Michigan division. The one on the Canada division had 72-inch drivers; it was designed for fast passenger service and did not prove to be as good for that service as the one on the Michigan division. I am fully convinced that economy will result from the use of the compound locomotive.

MR. E. W. PRATT (C. & N.-W. Ry.): I had occasion, some time ago, to look up some figures comparing the compound locomotive with the simple locomotive, and I want to make one remark

in reply to Mr. Herr's statement relative to the advisability of using 190 pounds of steam for simple engines and 200 pounds pressure for the compound. Doubtless many of you have seen figures obtained in an extensive test made on the Caledonian railway in England, in passenger service entirely, which showed that the most economical boiler pressure for passenger service was, if I remember right, very close to 160 pounds for a simple engine. The port conditions and valve conditions have doubtless been improved since that time, but I believe it is a settled question that a steam pressure of less than 200 pounds for a simple engine will be more economical, as far as the coal pile is concerned, than pressures above 200 pounds; therefore, I am inclined to think that the lower steam pressure is favorable to the simple engine instead of otherwise.

MR. STREET: I do not like to stand under that implication of being ten years behind the times. I believe that Mr. Manchester's figures show that Mr. Barr is about ten years behind the times, inasmuch as his locomotives are loaded to about half their capacity.

MR. BARR: I do not know why he says we are running our engines at half capacity. If he will look at the diagram he will see that, at forty-eight miles an hour, an 800-ton load takes just as much engine as a 1,600-ton load at twenty-five miles an hour, and I do not see that the figures show that we haul 700 tons where we could haul 1,200 tons.

THE CHAIRMAN: Mr. Herr, the members have asked a question or two on which you can probably give some information.

MR. HERR: I will try to answer Mr. Pomeroy's question in regard to the flexibility of the compound. I think that the compound is not as flexible as the simple, using the word "flexible" to mean the variations under which the compound can work without suffering a loss of economy; I judge that is what Mr. Pomeroy means. The economy of the compound is very much reduced when the engine is worked too lightly; allow me to say a word now in regard to the use of the compound in passenger service. I agree entirely with the majority of the speakers, perhaps with all of them who have said anything in regard to the use of the compound in passenger service, that it is advantageous in heavy fast passenger service, especially so in the very fast service; and the reason it is economical and advantageous is because in that service the boiler is taxed the hardest, the greatest amount of

horse power is required and the simple engine is unable to furnish it, and, consequently, the compound has the advantage in being able to furnish more horse power. But if the same compound works on a lighter run at the same speed, where the simple engine is not taxed so severely and is not worked below the most economical point of cut-off, the compound will not show so advantageously. The compound does not drift as easily as the simple engine, generally; it is true that considerable improvement has been made in that respect recently, but with the double cylinders, as in the case of the 4-cylinder compound, and the larger piston, in the case of the 2-cylinder compound, my experience indicates that the compound shows a noticeable difference in the ease with which it drifts. Now, in a very light passenger service a locomotive is drifting much of the time, or at least working steam so light that it is practically drifting, and when this condition is approached the compound immediately begins to decrease in economy. The relative value of compound and simple engines in passenger service is something that I have investigated a good deal, in replacing passenger engines on the Northern Pacific road. It became necessary not long ago, on account of the heavier trains that had to be hauled, to decide on what divisions the compounds should be used, and on what divisions simple engines should be used, and whether compounds should be used entirely. The experience with the compounds was all on one division, which, it is true, is quite diverse as to gradients, and it was from that experience we had to determine what the disposition of the compound and simple engines should be on the entire extent of line of the Northern Pacific road, covering a distance of over 2,000 miles. The outcome of the research was that it was decided to put compound locomotives on just one-half of the divisions. The compound engines were put where it was thought the heaviest work was to be done. On two divisions of the road adjoining each other, one just east of the Rocky mountains, the other just west, it was quite a question as to which one of those divisions should have the simple and which the compound, or whether both should have the compounds—both were pretty heavy divisions. It was finally decided that on one should be the simple engines and on the other compounds, and I had arranged for a test, as a matter of information, to change these engines after they had been running three months, and run the compounds on the division to which the

simples had been assigned, and the simples on the division to which the compounds had been assigned. That was done after I left the road. I have learned since then that the test showed that the original disposition of the engines was the correct one, although the economy of the compound over the simple on the division on which the compound was originally placed was very slight indeed; it was almost a "toss-up" whether the compound or the simple should be used in that particular service. There are other divisions on which the work is lighter, and I am very well satisfied that if we had had the compound instead of the simple on those divisions we would have suffered a loss in fuel; and on that account I think we should be a little cautious as to how the compound is used in passenger service, because, generally, the engines are not worked in passenger service beyond the most economical point of cut-off for the simple engine, and worked pretty light on the down grades. The ideal place, in my judgment, for compound engines is on level divisions in freight service. That may seem strange, because nearly everybody who talks about compounds, favors them for heavy mountain service, or hill service, or something of that sort, but it must always be remembered that the hill has two sides, that the engine that goes up must come down, and while the compound shows splendid economy going up the hill, it will do the reverse coming down. On a level division, if the operation is correct, there ought to be an economy as a result of working steam both ways. The paper calls attention to this condition in the case of the Second Minnesota division, diagram B, in which, while it is not a level division by any means, the configuration is more nearly like a level division, and the service makes it more so, because at Winnipeg Junction the train load is increased by the traffic that comes in from the Manitoba division and enables loading the engine to its capacity the entire length of the division; then, in the opposite direction, you will see on Profile B, that the character of the profile is such that there are no heavy grades and the engine can be loaded almost constantly in the reverse direction, and it is on that division the compound engine in regular road service showed in some instances 28 per cent. economy in fuel over the simple, and I am sure over 20 per cent. can be obtained year in and year out.

The question which Mr. Pomeroy raised as to cylinder ratio is one on which I cannot speak with any degree of certainty. I believe

that it is not possible from any road tests that can be made, to say much about the proper cylinder ratio. The place, in my judgment to test cylinder ratio is on a testing plant such as they have at Purdue, or such as Mr. Marshall has at his disposition. I know there has been work done on both these plants along this line. The matter of cylinder ratio, which was tested on the Northern Pacific road, is referred to in Mr. Lovell's discussion of the paper, in the test he made on Bozeman mountain with the mastodon type of engine. I had the cylinders of one of those engines bushed to 22 inches in diameter, from 23 inches, thinking that in that severe service, increasing the cylinder ratio we could produce greater economy; but the experiment failed, because while we increased the cylinder ratio, we at the same time decreased the total power of the engine, which, of course, decreased its efficiency, and one cannot say which produced the undesirable result. The entire result was not as good as with the lower cylinder ratio and larger high pressure cylinder. The results of that experiment are not conclusive, I think, and I gave up the idea of testing cylinder ratios after I had made that experiment, believing the road was not the place to do it.

Mr. Barr spoke pretty positively about the advantage of using the compound engine in passenger service, stating that inasmuch as it saves about 15 per cent. in water, there was undoubtedly a great field for the engine where so much horse power is used. I entirely agree with him, with the exception that you must be pretty sure that your service is such that your engine is going to save the 15 per cent. in water, because if it does not you do not get the economy, but where there is very heavy service, there is no doubt but that is exactly the place to use the compound.

I am fully cognizant of the fact that a good many things in the paper are, on the face of them, open to a great deal of criticism. Some of these dots and points on the diagrams look rather peculiar, and I had hoped that in the discussion attention would be called to them. I cannot explain them all, but I can some of them, and I am very glad to throw any light in my power on points that may be brought up. I will simply call attention to diagram D. There are two points that are a little peculiar. You will notice that in the months of September and November the simple engine actually showed less economy during the first month than the compound engine; in the second month showing the same economy as the com-

pound engine. It is also interesting to know as an indication of how long a compound engine can be kept running under adverse conditions. This is a ten-wheel engine with 112,000 pounds on the drivers, with 22x26-inch high-pressure and 34x26-inch low-pressure cylinders carrying 200 pounds steam pressure. As shown in the diagram, it hauls a train of between 500 and 600 tons over a profile of road, the gradients of which vary from a level to about eighty feet grade, a large proportion of it being grade, as you will notice, especially on the second district; the engine hauls a train, often consisting of fifteen cars, four or five of them sleepers and dining cars, on a schedule averaging between 30 and 32 miles an hour, making a great many stops, a distance of 273 miles; there is no changing of engines in that 273-mile run. The engines are double and triple crewed and have been in that service two years in June. They make regularly about 8,600 miles a month. In that service in the month of September the simple engine happened to get trains pretty regularly on time, while the compound engine happened to get a number of badly delayed trains and made up on that run, in a number of cases, from forty minutes to an hour. Of course it could not be expected to make the run in forty minutes to an hour less time than another engine and not burn more coal. At the same time the character of the coal in those two months, which, of course, both engines used, was very bad. When making up time and working very hard, it is hard enough if the locomotive has good coal, but if it has very bad coal, it is still harder and still more of a tax upon the amount of fuel consumed. In the months of April and July, the following year, you will notice that the compound made quite a noticeable increase in economy over the simple; in those months the reverse condition took place; then the simple engine had the delayed trains, and the compound had the trains that were on time, and of course the compound showed better economy. You cannot expect any record of road service to have diagrams that will show anything like continuous or uniform economy, because there is nothing like a uniform set of conditions in practical train operation.

In regard to the point raised by Mr. Pratt, that 160 pounds of steam is the limit of economy; in simple stationary engines that is, I believe, true. He states that some tests had been made and results obtained as stated. In stationary service it has also been demonstrated, I believe, that there is no advantage in getting higher

pressure of steam to produce economy in simple engines. There are different conditions in locomotive performance, and I am not at all sure that there is not some gain in getting pretty high steam pressure, even as high as 180 pounds to the square inch, over 150. I made a test of that sort on a mountain engine, and while the results may not serve for general application, nevertheless in certain conditions of service I think it is very possible that there may be economy in these higher pressures, even for the simple engines. The test was made on the Northern Pacific road on the Cascade mountains, by taking one of the consolidation mountain helper engines, weighing 135,000 pounds on the drivers, and strengthening the boiler and increasing the steam pressure to 180 pounds per square inch, with 150 pounds per square inch on the other similar engines. These engines had cylinders originally 22-inch diameter and 28-inch stroke; we bushed the cylinder of one engine carrying 180 pounds steam pressure, so that the tractive power of the high pressure engine would be the same as that of the low pressure engine. That engine was put into service beside the engine with unbushed cylinders, together with a 4-cylinder compound of the same type carrying 180 pounds of steam, and it was rather curious to see those engines, after a few months' service, take just the following relative positions—the compound engine first, then the engine with the bushed cylinders, and the engine with the unbushed cylinders below; they stood that way for a number of months, and I had reason to believe that they would stand in that order permanently if allowed to run under those conditions.

On motion the discussion was declared closed.

THE CHAIRMAN: The next paper is entitled "High Speed Passenger Locomotives," and is by Mr. Clement F. Street.

HIGH SPEED PASSENGER LOCOMOTIVES.

BY MR. CLEMENT F. STREET.

The writer was, a few months ago, requested to collect some data regarding the locomotives used in this country in high speed passenger service, and in attempting to comply with the request found that such data was scattered and incomplete. It was, therefore, determined to go into the subject deeper than at first intended, and compile a partial record of the important features of some of the locomotives used on the largest roads, and also of the service in which they are employed. The result will be found in the accompanying illustrations and tables. These relate to twenty-one different locomotives which are in use on eighteen different roads. Eleven of them have four drivers coupled and ten have six coupled, seven being eight-wheelers, four Atlantic or Columbian, nine ten-wheelers and one a mogul. Some of them are of new designs, which have not been in use one year, while others have been in regular and hard service for many years and are still hauling some of the fastest and heaviest passenger trains in the country. In making a selection no definite plan was followed, and these particular engines are given because they, in the opinion of the writer, represent fairly well the prevailing practice for single expansion engines in fast passenger service. The record is in no way complete, as there are large numbers of other locomotives in service just as severe and doing work just as creditable as those here given.

In the accompanying illustrations, Figs. 1 to 21, inclusive, will be found a reproduction of either a photograph or drawing of each of the locomotives, and beneath most of them will be found data regarding the trains they are hauling, together with the speed and number of stops called for by the published time card. Table No. 1 gives some of the important dimensions of the engines, and Table No. 2 gives the data regarding the tractive power, heating surface, piston speed, etc., together with averages. In figuring the tractive power, 80 per cent. of the boiler pressure is used, for the reason that this is the practice with some of the locomotive builders, as well as a number of the railways. It appears that the Master Mechanics' Association has no fixed rule regarding this proportion, and the only information thereon which I can find is a committee report read at the annual convention in 1887. This report contains a recommendation that 85 per cent. be used, but the only action of the association seems to have been the acceptance of the report without adopting its recommendations.

It will be noted that in Table No. 2 locomotive No. 12 is not included in the averages. The reason for this is that this can hardly be called a high speed engine, and it is in many ways a departure from prevailing practice. It was thought best to give it, however, as it is claimed that it is the heaviest locomotive in regular passenger service. Another reason for giving it is the fact that it has frequently been said that this engine was over cylindered. If

such is the case it is not the only one open to this criticism, as the relation between the weight and tractive power is only 4.53 per cent. above the average of the other nine ten-wheelers given; it is only 1.02 per cent. above the highest, and among the eight-wheelers there is one engine in which this proportion is greater. The cylinder volume in relation to the heating surface is less than that of six other ten-wheelers, and it would therefore seem that there should be no difficulty in supplying steam.

It will be noted from Table No. 2 that in order to attain a speed of sixty miles per hour with this engine the drivers must make 320 revolutions per minute, and the piston speed will be 1,600 feet per minute. In what is to-day termed high speed passenger service this speed and much higher must be maintained for long distances, and as it is believed that this is not practical the statement is made that this engine is not suited for high speed passenger service. This engine was, I believe, designed to haul heavy passenger trains over very heavy, long grades, and published reports state that it is well suited for this service, and is using much less fuel than engines having shorter stroke and less tractive power.

One of the interesting features of Table No. 1, is the variation in the cylinder proportions and the diameter of drivers. In the eight-wheelers the cylinders range from 18 x 24 up to 20 x 26 inches. Three of them have 19 x 26-inch cylinders and with these are used drivers 73, 76 and 84 inches in diameter. There are three 19 x 24-inch cylinders, and with them drivers of 72, 75 and 78 inches are used. No two of the remaining five eight-wheelers have the same size cylinder. In the ten-wheelers the variation in cylinder dimensions is greater and that in diameter of drivers is less. The cylinders range from 18 x 24 up to 20 x 30 inches and only two are of the same size. The average diameter of drivers on the eight-wheelers is 76.2 inches, while on the ten-wheelers it is only 68.7 inches. In the former there are five engines having drivers 78 inches and above, while in the latter there is only one of 78 inches and the next larger is 72 inches. Seven of this class have drivers 69 inches and under.

This question of diameter of drivers has been the subject of many discussions and it is one on which no hard and fast rule can be laid down, as it must be varied to suit conditions of service and road bed. There was, however, some years ago a tendency to reduce the diameter of drivers from former practice, but of late there has been a reaction and we find more large drivers in use than ever before in this country. There are good and valid reasons for this change. With the high speeds and long runs now demanded, a small driver must be turned so rapidly for long periods of time that the high journal and piston speeds are liable to give trouble. The wear and tear on the track and the engine itself is excessive. A 63-inch driver turning 325 revolutions a minute looks from the cab to be going at a tremendous speed, and the engine it carries will make a much greater fuss about it and ride harder than in turning a 72-inch driver the same number of revolutions. The liability to hot boxes and pins is greater with small than with large drivers. On one of the trunk lines a certain class of engine was giving serious trouble from hot journals. Delays from this cause became so frequent that there was talk of putting the engines in another

service, but before doing so the drivers on one of them were increased six inches in diameter. The result was that the trouble entirely disappeared and the other engines of the same class were changed with like result and are now giving satisfactory results where they had formerly failed.

The increase in the diameter of the drivers naturally follows an increase in steam pressure. With the former pressure of 140 to 150 pounds it was, with large drivers, difficult to obtain sufficient tractive power for starting heavy trains, but with the present practice of carrying 190 to 200 pounds, this does not obtain. It is true that the weight of the trains to be hauled has also been increased, but, on the other hand, the number of stops made by through fast trains is much less than formerly. Runs of from 80 to 100 miles without a stop are now made regularly on a large number of roads while only a few years ago they were exceptional.

Another change in high speed passenger service is the introduction of the Atlantic type of engine, and the indications are that this will eventually be the most used type for heavy high speed work, where the demands on the boiler are so great that it must be made too heavy to carry on two axles and the truck. This type has many advantages over the ten-wheeler and it is not apparent just where there can be any advantage in using a third pair of drivers for passenger service, excepting for a few revolutions at starting. After the train is once under way two pair of drivers will give ample tractive power, and if a third pair is used it becomes superfluous weight to carry. It also furnishes an extra pair of rods and pins to look after, and it is not believed that the slight advantage gained at starting will compensate for this extra work. One of the most important advantages attending the use of the trailing wheel is that with it the frame can be dropped and the fire-box given greater depth than where the third driver is put in.

The ten-wheeler is a more all around engine than any other style in use. It can be used for hauling heavy freight trains at high speeds, heavy passenger trains, local trains of either class, and in any ordinary service a few extra stops or extra cars have very little effect on it, one way or the other. During the World's Fair a large proportion of the long, heavy excursion trains which came into Chicago were hauled by ten-wheelers designed for freight service, and the superintendent of motive power who had available engines of this type was a fortunate individual. When it comes, however, to a regular heavy, fast passenger service with comparatively few stops, the Atlantic type is an easier riding, smoother working machine, and is fast coming into more extended use.

There has, of late, been considerable talk about long stroke engines, and some are arguing in favor of them for passenger service. These arguments have, however, very little, if any, solid foundation, and are more in line with the old rule-of-thumb methods than in accordance with modern engineering practice. By referring to Table No. 1 it will be seen that only two of the engines given have a stroke of over twenty-six inches. If a greater tractive power was found desirable in any one of these engines it is believed that it would be much better to obtain it by increasing the diameter rather than the stroke of the cylinder. For example, take engine No. 4. The cylinder is 19x26 inches and the tractive power 17872 pounds. An increase of one inch in the

diameter of the cylinder would give 19,897 pounds without changing any other part of the machine, excepting a slight increase in the counterbalance to take care of an increase in the weight of reciprocating parts. An increase of two inches in the stroke of the engine would give 19,252 pounds tractive power, and would increase the piston speed, while running sixty miles per hour, from 1,056 to 1,137 feet per minute. This increase in the piston speed increases the cylinder wear and the liability to trouble with piston rings. It also makes a much harder riding engine, and increases the wear and tear on both the engine and track. Just why an increase in tractive power, by lengthening the stroke, is better than a corresponding increase obtained by increasing the diameter of the cylinder is not apparent. It is stated that with the long stroke more work is obtained from the steam, owing to a greater expansion. This is true, but at high speeds and the short points of cut off which go with them an extra inch or two on the stroke amounts to very little. If an engine is working at a cut off of one-half stroke or over, as in heavy freight service, each extra inch of stroke means a considerable increase in the power of the engine and also in the work obtained from the steam. Even in this service, however, it is a very easy matter to get the stroke so long that when high speeds are attained, as they must be, and when running down hill the "slam banging" of the machine is hard on the crew and roadbed as well as the engine itself.

In the foregoing, no attempt has been made to enter deeply into the subject in hand, and the object in presenting it in this form is, as before stated, merely that of placing in get-at-able form a record of what is being done in the way of locomotives for fast passenger service. The ground covered is only a very small fraction of that which could be. The compound locomotive, which is being extensively used is not touched on at all, the information given regarding conditions of service is not so complete as it should be and the tables would be more valuable if they included a greater number of engines. This subject is one of interest and importance, the information desired can most of it be secured without difficulty, and it is believed that it would be of greater value if submitted each year in the form of a committee report.

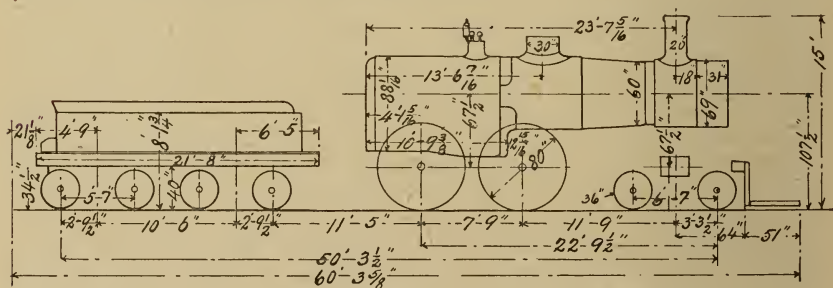


Fig. 1.

No. 1, Pennsylvania Railroad.—Hauls Pennsylvania Limited Jersey City to Pittsburgh. Distance, 444 miles. No. station stops, 3. Running time, 11 hours. Average speed, including stops, 40.3 M.P.H.



Fig. 2.

No. 2, Wabash Railroad Co.—Hauls Continental Limited between St. Louis and Detroit. Distance, 431 miles. No. of cars, 3. Weight, exclusive of engine and tender, 164 tons. Heaviest grade, feet per mile, $48\frac{3}{8}$. Heaviest grade, length, $2\frac{1}{4}$ miles. No. station stops, 17. Running time, 11 hours 50 minutes. Average speed, including stops, 40.7 M.P.H. December 18, 1898, run from Tilton to Decatur, 71 miles, was made in 61 minutes. August 20, 1898, run from Palmer to Norrisonville, 4.6 miles, was made at the rate of 90 M.P.H.; from Mitchell to Nameobi, 2.5 miles, was made at the rate of 100 M.P.H. October 6, 1898, run from Clarksdale to Palmer, 3.3 miles, was made at the rate of 99 M.P.H., and from Palmer to Norrisonville at the rate of 90 M.P.H.



Fig. 3.

No. 3, New York Central and Hudson River R. R.—Fastest train, Empire State Express, New York and Buffalo, 440 miles. No. of cars, 4. No. station stops, 4. Running time, 8 hours 15 minutes. Average speed, 53.3 M.P.H.

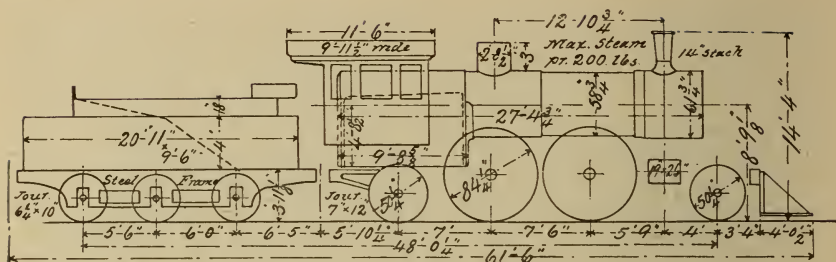


Fig. 4.

No. 4, Chicago, Burlington & Quincy R. R.—Fastest regular train, Chicago to Burlington, 205 miles. No. of cars, 4. Weight, exclusive of engine and tender, 200 tons. No. of stops, 2. Running time 3 hours 52 minutes. Average speed, including stops, 53.1 M.P.H.

RUN, MAKING UP LOST TIME, JAN. 2, 1899.

DISTANCE BETWEEN STATIONS.	TIME MINS.	STATIONS.		DELAYS.
43.3	43	L Burlington	10:42 P.M.	
		A Galesburg.....	11:25 "	4 m. mail
		L "	11:29 "	
79.7	73	A Mendota	12:42 A.M.	7 m. mail
		L "	12:49 "	
45.4	40 1/2	A Aurora.....	1:29 1/2 "	1 1/2 m. mail
		L "	1:31 "	
33.6	32	A West Avenue.....	2:03 "	1 m. stopping for
		L "	2:04 "	P. H. crossing.
3.8	11	A Union Depot	2:15 "	

205.8

Average speed while running, 61.8 M.P.H.



Fig. 5.

No. 5, Cleveland, Cincinnati, Chicago & St. Louis Ry.—Fastest regular train, St. Louis and Cleveland, 548 miles. No. of cars, 6. Weight, exclusive of engine and tender, 274 tons. Heaviest grade, feet per mile, 50. Heaviest grade, length, 2 1/2 miles. No. station stops, 21. Running time, 13 hours 50 minutes. Average speed, including stops, 39.62 M.P.H.

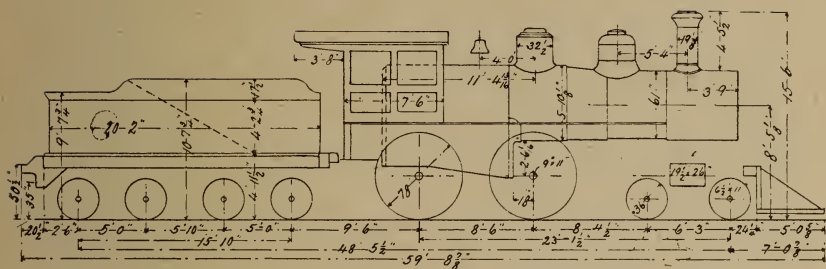


Fig. 6.

No. 6. Chicago, Rock Island & Pacific Ry.—Fastest regular train, Chicago and Omaha, 503 miles. Running time, 12 hours. Average speed, including stops, 41.9 M.P.H. This engine hauls a regular train, Chicago to Rock Island, 181 miles. No. of cars, 10. Weight, excluding engine and tender, 339 tons. Heaviest grade, feet per mile, 55. Heaviest grade, length, 5,500 feet. Running time, including stops, 4 hours 45 minutes. Average speed, 38.1 M.P.H.



Fig. 7.

No. 7. Lehigh Valley R. R.—Fastest regular train, Black Diamond Express, New York and Buffalo, 450 miles. No. of cars, 5. Weight, exclusive of engine and tender, 225 tons. Heaviest grade, 47 feet per mile for 4.5 miles. Heaviest grade, 62 feet per mile for 9.8 miles. No. station stops, 14. Running time, 10 hours 40 minutes. Average speed, including stops, 42.25 M.P.H. Alpina to Geneva Junction, 44 miles in 42 minutes.

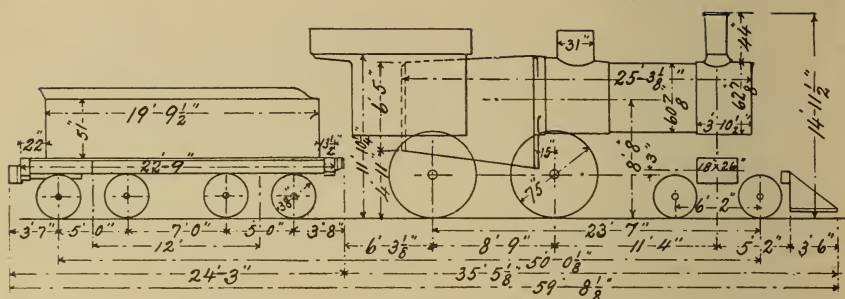


Fig. 8.

No. 8, Illinois Central R. R. Co.—Fastest regular train, Chicago and New Orleans, 923 miles. No. of cars, 7. Weight, exclusive of engine and tender, 240 tons. Heaviest grade, feet per mile, 36. No. station stops, 37. Running time, 26 hours. Average speed, including stops, 35 M.P.H. Chicago to Champaign, 128 miles, is made in 3 hours 15 minutes, making 18 regular stops. Maximum grade, 36 feet per mile. Average speed, 39.3 M.P.H.



Fig. 9.

No. 9, Chicago & North-Western Ry.—Fastest regular train, Chicago to Omaha, 490 miles. Weight of train, exclusive of engine and tender, 123 tons. No. of stops, 16. Running time, 12 hours. Average speed, including stops, 40.8 M.P.H. *Run is frequently made in 11 hours, or at an average of 44.5 M.P.H. This engine hauls 10 or 12 cars, weighing 423 to 513 tons, 138 miles in 3 1/2 hours, making 8 stops, or an average of 39.4 M.P.H. New Fast Mail makes the run in 10 hours 15 minutes, or 46.6 M.P.H., and has hauled this train 138 miles in 127 minutes.

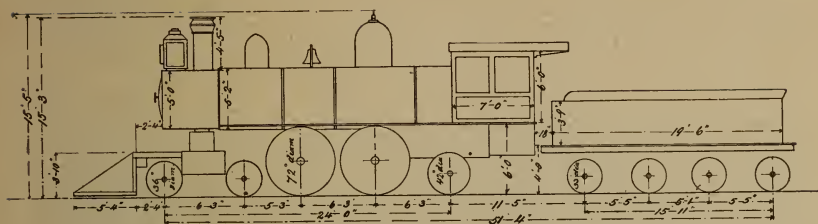


Fig. 10.

No. 10, Atlantic Coast Line.—Fastest regular train, Richmond & Charleston, 396 miles. No. of cars in train, 8. Weight, exclusive of engine and tender, 365 tons. Station stops, 12. Running time, 10 hours 33 minutes. Average speed, 37.7 M.P.H.

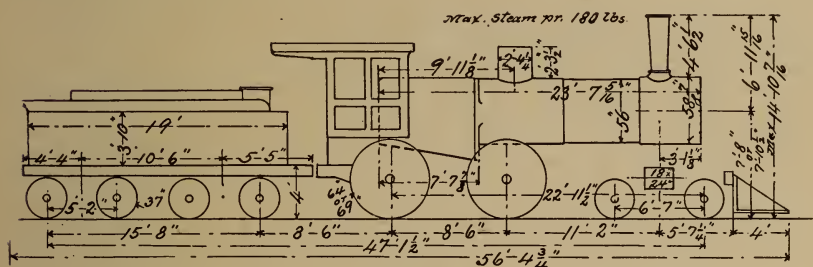


Fig. 11.

No. 11, Chicago, Burlington & Quincy R. R.—Fastest regular train between Creston and U. P. Transfer, 103.9 miles. No. of cars in train, 4. Weight, exclusive of engine and tender, 200 tons. Running time, 2 hours 30 minutes. Average speed, including stops, 41.5 M.P.H.

SPECIAL RUN, MAKING UP LOST TIME, JAN. 2, 1899.

MILES FROM U. P. TRANSFER	MILES BETWEEN STATIONS.	TIME MINS.	STATIONS.		DELAYS.
0			L U. P. Transfer..	4:52 P.M.	1 h. 2 m. late
18.3	18.3	21	A Pacific Jct.....	5:13 "	1 m. mail
			L " ".....	5:14 "	
52.8	34 5	39	A Red Oak.....	5:53 "	1 m. mail
			L " ".....	5:54 "	
68.5	15.7	19	A Villisca.....	6:13 "	1 m. mail
			L " ".....	6:14 "	
103.9	35.4	37	A Creston.....	6:51 "	

Average speed while running, 53.8 M.P.H.



Fig. 12.

No. 12, Great Northern Ry.—



Fig. 13.

No. 13, Grand Trunk Ry.—Fastest regular train, Port Huron and Chicago, 335 miles. No. of cars, 7 to 14. Heaviest grade, feet per mile, 52.8. Heaviest grade, length, 2,500 feet. No. station stops, 13. Running time, 8 hours 45 minutes. Average speed, including stops, 38.2 M.P.H.

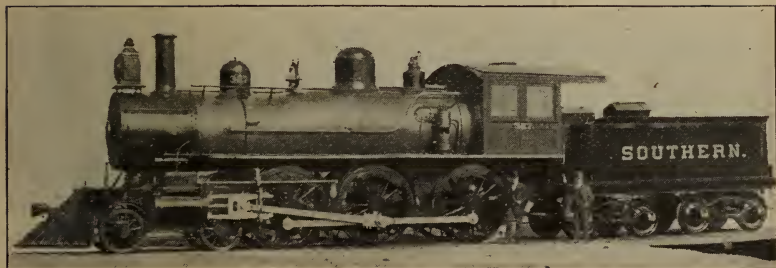


Fig. 14.

No. 14, Southern Railway Co.—

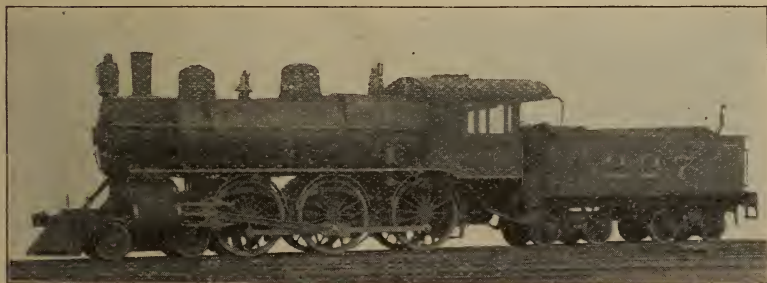


Fig. 15.

No. 15, Wisconsin Central Lines.—Fastest regular train, Chicago to St. Paul, 462 miles. No. station stops, 19. Running time, 13 hours 50 minutes. Average speed, 33.4 M.P.H.

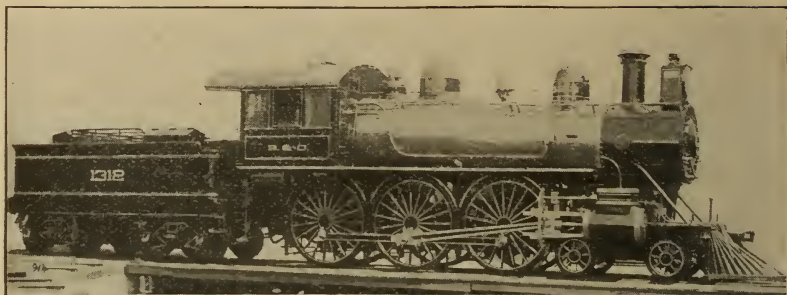


Fig. 16.

No. 16, Baltimore & Ohio R. R.—Fastest regular train, Philadelphia to Washington, distance 137 miles. Heaviest grade, feet per mile, 40. Heaviest grade, length, 1 mile. No. cars in train, 4. Weight of train, exclusive of engine and tender, 169 tons. No. station stops, 2. Running time, 2 hours 53 minutes. Average speed, including stops, 47.2 M.P.H. Special runs with 4-car train weighing 192 tons, Baltimore to Washington, 40 miles, at 66.3 M.P.H. Laurel to Washington, 19 miles, at 74 M.P.H. Regular run, Camden to Washington, with 9-car train weighing 339 tons, 40 miles in 50 minutes, or 48 M.P.H.



Fig. 17.

No. 17, Northern Pacific Ry.—Fastest train, St. Paul to Fargo, distance 251 miles. No. of cars in train, 11. Weight, exclusive of engine and tender, 395 tons. Heaviest grade, feet per mile, 26. Heaviest grade, length, 5 miles. No. station stops, 10. Running time, 8 hours. Average speed, exclusive of stops, 31.3 M.P.H. A speed of 83 M.P.H. has been attained by this engine.

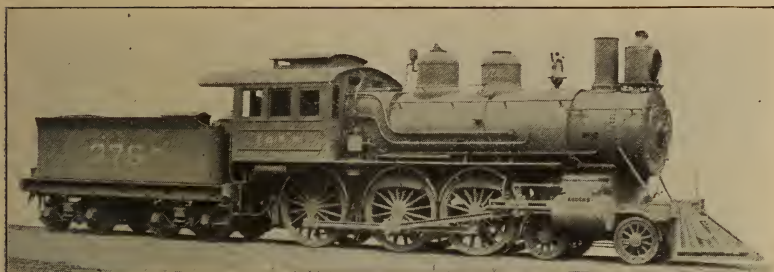


Fig. 18.

No. 18, Illinois Central R. R.—Fastest train, Louisville to Paducah, distance 226 miles. Heaviest grade, 36 feet per mile. No. station stops, 7. Running time, 6 hours 15 minutes. Average speed, including stops, 36.3 M.P.H. Special run, Grenada to Canton, 88¼ miles, with 12 sleepers weighing 500 tons, making 2 regular stops, in 2 hours 7 minutes. Maximum grade, 36 feet per mile. Average speed, 42 M.P.H.

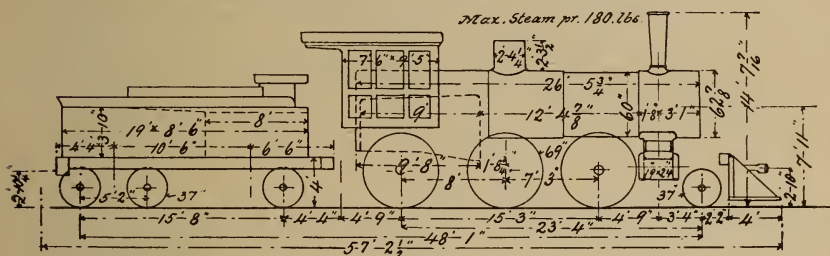


Fig. 19.

No. 19, Chicago, Burlington & Quincy R. R.—Fastest regular train between Burlington and Creston, 190 miles. No. of cars, 4. Weight, exclusive of engine and tender, 200 tons. No. of stops, 5. Running time, 3 hours 58 minutes. Average speed, including stops, 47.4 M.P.H.

SPECIAL RUN, MAKING UP TIME, JAN. 2, 1899.

MILES BETWEEN STATIONS.	TIME MINS.	STATIONS.		DELAYS.
34.3	37	L Creston.....	6:58 P.M.	
		A Osceola.....	7:35 "	1 m. mail
25.7	28	L ".....	7:36 "	
		A Chariton.....	8:04 "	4 m. mail and hot
		L ".....	8:08 "	box on car
30.5	32	A Albia.....	8:40 "	2 m. mail
		L ".....	8:42 "	
24.2	27	A Ottumwa.....	9:09 "	3 m. mail
		L ".....	9:12 "	
25.1	29	A Fairfield.....	9:41 "	2 m. mail
		L ".....	9:43 "	
50.7	55	A Burlington.....	10:38 "	4 m. changing engi'e

Average speed while running, 52.0 M.P.H.



Fig. 20.

No. 20, Michigan Central R. R.—Fastest regular train, Chicago & Buffalo, 535 miles. No. of cars, 9. Weight, exclusive of engine and tender, 377 tons. Heaviest grade, feet per mile, 36. Heaviest grade, length, 2 miles. No. station stops, 27. Running time (not including 45 minutes ferrying at Detroit), 14 hours 45 minutes. Average speed, including stops, 36.2 M.P.H.



Fig. 21.

No. 21, Lake Shore & Michigan Southern Ry.—Fastest regular train, Lakeside Limited No. 22, Chicago and Buffalo, 540 miles. No. of cars, 8. Weight, exclusive of engine and tender, 485 tons. Heaviest grade, feet per mile, 26. Heaviest grade, length, 3-10 miles. No. station stops, 6. Running time, 13 hours 20 minutes. Average speed, including stops, 40.5 M.P.H.

No.	NAME OF ROAD	TYPE	TRACTION POWER PER. LB. M.E.P.	TRACTION POWER WITH M.E.P. EQUAL 80 % OF BOILER PRESSURE	TRACTION POWER PER. CENT WEIGHT ON DRIVERS	GRATE AREA INTO HEATING SURFACE	CYL. VOLUME CU. FT. INTO HEATING SURFACE SQ. FT.	CYL. VOLUME CU. FT. INTO GRATE AREA SQ. FT.	REVS. REQUIRED TO RUN 60 M.P.H.	PISTON SPEED FT. PER. M. WHILE RUNNING 60 M.P.H.
1	PENN. RY.	8-W	111.2	164.57	17.67	58.12	237	4.08	252	1091
2	WABASH	COL.	128.5	20.560	22.34	79.53	277	3.49	276	1195
3	N.Y.C. & H.R.	8.W	111.0	168.72	18.73	63.26	251	3.97	259	1036
4	C.B. & Q.	COL.	111.7	17.872	21.04	50.29	187	3.73	244	1056
5	C.C.C. & ST.L.	8.W	133.3	21.328	25.09	69.74	229	3.28	244	1121
6	C.R.I. & P.	8.W	126.7	19.258	23.20	81.15	221	2.72	259	1121
7	LEHIGH VAL.	COL.	123.5	17.784	21.69	34.84	261		265	1147
8	ILL. CTL.	8.W	112.3	17.968	22.46	65.73	235	3.87	269	1264
9	C. & N.W.	8.W	115.5	17.556	22.50	69.32	238	3.40	269	1076
10	ATL. C. LINE	COL.	120.3	17.323	23.60	78.73	260	3.30	280	1120
11	C.B. & Q.	8.W	112.6	16.214	24.56	57.49	199	3.46	290	1160
	AVERAGE		118.5	18.108	22.08	64.38	235	3.53	265	1126
12	GRT. NOR ^x	10.W.	190.4	31.987	24.70	75.62	245	3.24	320	1600
13	GRD. TRUNK	10.W.	144.4	23.104	18.48	73.61	260	3.60	280	1212
14	SOUTHERN	10.W.	171.5	27.440	22.63	69.05	215	3.11	280	1304
15	WIS. CTL.	10.W.	136.0	21.760	18.75	70.98	269	3.91	290	1255
16	B. & O.	10.W.	147.0	22.344	19.77	62.90	207	3.30	259	1121
17	NOR. PAC.	10.W.	150.7	26.523	23.68	80.68	263	3.33	290	1255
18	ILL. CTL.	10.W.	143.2	22.912	21.02	72.53	226	3.11	290	1255
19	C.B. & Q.	MOGUL	125.5	18.072	16.96	56.77	214	3.77	290	1160
20	MICH. CTL.	10.W.	127.3	18.331	18.51	59.78	216	3.63	296	1184
21	L.S. & M.S.	10.W.	114.3	17.373	19.74	68.35	164	3.86	296	1184
	AVERAGE.		139.9	21.984	19.95	68.29	226	3.51	285	1214

x NOT INCLUDED IN AVERAGE

No.	NAME OF ROAD	CYLIN- DERS.	WEIGHT ON DRIVERS	HEATING SURFACE		TUBES			FIRE BOX		TYPE OF BOILER	MAIN JOURNAL		VALVE		STEAM PORTS.		TOP OF RAIL TO CENTER OF BOILER							
				SQ. FT.	TOTAL	No.	DIA	LENGTH	WIDTH	LENGTH		SMALLEST KIND OF BOILER	DIA.	LENGTH	TRAVEL	LAP	LENGTH		WIDTH						
1	PENNA RY	8 W.	134,500	93,100	1746.7	171.4	1918.1	330	185	119 1/8	4.0	119 1/8	58 1/2	8 1/2	12 1/2	6	1 1/8	20	1 1/2	107 1/2					
2	WABASH	ATL.	191*26	73	160,000	92,000	2190.3	175.7	2366.0	297	200	310	2	171	42 1/2	101 1/2	60	9	10	1 1/8	103				
3	N.Y.C. & H.R.R.	8 W.	191*24	78	136,000	90,100	1810.0	164.0	1974.0	312	190	288	2	144	45 1/2	117 1/2	60	9	12 1/2	1 1/8	105 1/8				
4	C.B. & Q. R. Y.	COL.	191*26	84	28,700	84,450	1442.3	157.2	1595.5	31.8	200	210	2	159 1/2	42 1/2	108 1/2	58 1/2	8 1/2	12	1 1/2	105 1/8				
5	C.C. & S. L.	8 W.	201*26	78	130,000	85,000	1997.0	165.0	2162.0	31.0	200	320	2	144	41	108	62	8 1/2	11 1/2	20	1 1/8	105 1/2			
6	C.R.I. & P. RY	8 W.	191*26	78	125,000	83,000	1795.0	193.3	1988.3	24.5	190	296	2	139	32 1/2	108	61	9	11	6	1 1/8	20	1 1/2	101 1/2	
7	LEHIGH VAL	ATL.	191*26	76	142,000	92,000	2081.2	148.9	2230.8	64.0	180	216	2	181	83 1/2	114 1/2	70	8 1/2	11	5 1/8	1 1/8	19	1 1/8	106 1/2	
8	ILL. CTL	8 W.	181*26	75	120,000	80,000	1645.0	192.9	1801.0	27.4	200	274	2	135 1/2	36 1/2	107 1/2	60 1/2	8 1/2	11	6	7/8	17	1 1/2	104	
9	C. & N. W.	8 W.	191*24	75	125,600	78,000	1715.6	153.3	1874.9	26.9	190	287	2	138	40 1/2	96 1/2	61	8	11	6	1 1/2	20	1 1/8	104	
10	ATL. C. LINE	ATL.	191*24	72	123,800	73,400	1913.7	133.5	2047.2	26.0	180	258	2	171	42	89 1/2	58 1/2	8	10	5 1/2	7/8	16	1 1/8	97	
11	C.B. & Q. R. Y.	8 W.	181*24	69	100,000	66,000	1298.7	110.0	1408.7	24.5	180	217	2	136 1/8	42	84	56	8	9 1/2	6	1 1/8	17 1/2	1 1/2	94 1/2	
	AVERAGE		189*25 1/2	76 1/2	129182	82459	1785.4	160.9	1942.7	31.8	190	270		160*4	44.3	105*4									
12	GRT. NOR	10 W.	201*30	63	166,000	129,500	2432.0	225.0	2677.0	35.4	210	303	2 1/2	166 1/2	41 1/2	123	70	9	11	7	1 1/8	18	2	105 1/2	
13	GRO. TRUNK	"	201*26	72	168,000	125,000	2272.0	189.0	2461.0	33.4	200	291	2	180	40 1/2	120	62	9 1/2	12						
14	SOUTHERN	"	211*28	72	158,000	121,120	2217.1	192.9	2410.1	34.9	200	295	2	152 1/2	41 1/2	120		62	8 1/2	11					100 1/2
15	WIS. CTL	"	191*26	69	150,000	116,000	2111.0	189.0	2300.0	32.4	200	308	2	158 1/2	41 1/2	113	66	9	11	7	1 1/8	18	2	107	
16	B. & O	"	211*26	78	145,200	113,000	1978.5	176.6	2155.1	34.2	190	231	2 1/2	174 1/2	41 1/2	120 1/2	60	8	10	5 1/2				104 1/2	
17	NOR. PAC.	"	201*26	69	153,500	112,000	2288.0	196.9	2485.0	30.8	220	314	2	168	41	108 1/2		62	9	11	6 1/2	18	2 1/8	102 1/8	
18	ILL. CTL.	"	191*26	69	144,500	109,000	1854.6	177.1	2031.7	28.0	200	264	2	161	32 1/2	122 1/2	68	8	10 1/2	5 3/8	1	20	1 1/2	101	
19	C.B. & Q	10 W.	191*24	68	132,000	93,000	1566.7	137.1	1693.1	29.7	180	214	2	148 1/8	42	108		60	8	9 1/2	5	7/8	17 1/2	1 1/2	95
20	MICH. CTL	10 W.	181*24	68	118,000	88,000	1715.0	150.0	1866.0	27.3	190	241	2	150	43	96	57	7 1/2	8 1/2	5 1/2	7/8	18	1 1/8	98	
21	C.S. & M. S.	10 W.	191*24	68	118,000	88,000	1715.0	150.0	1866.0	27.3	190	241	2	150	43	96	57	7 1/2	8 1/2	5 1/2	7/8	18	1 1/8	98	
	AVERAGE		196*26	63 7/8	146020	111921	2000.0	176.9	2167.8	31.4	197	270		161	40.6	112.6		56 1/2	9	5	1	17	1 1/8	1 1/2	96

DISCUSSION.

THE CHAIRMAN: Mr. Street, will you please direct particular attention to the important points made in your paper?

MR. STREET: I wish to emphasize the fact that the paper is given more as a partial record of what is being done in the line of high speed passenger locomotives than in the way of criticising any individual practice which is being followed. The engines selected, as stated, are taken as representing as nearly as possible, the customary practice. The compound locomotive has not been considered. One reason for which was the fact that there is very little variation in compound locomotives used in passenger service, and it is rather a difficult matter to compare them with the single expansion engines in the manner in which the single expansion engine may be compared with themselves; if the compounds had been considered it would have been better to arrange them in tables by themselves.

There are one or two points in the paper that are, I think, of considerable interest; one is the question of diameter of driver, and the other the question of stroke of piston. As stated in the paper, I think that for high speed passenger service the use of a long stroke is questionable.

MR. J. O. PATTEE (Great Northern Ry.): In the advance sheets, of papers to be read before the Western Railway Club, there are given the dimensions of one of the Great Northern mountain engines among the so-called fast passenger engines. Herewith is a similar statement taken from one of our ten-wheel engines, which is standard on the level or outside of the mountain divisions, which I think will be a little less misleading than the one published (No. 12), and which is quite out of proportion to the other engines, for the reason that it is for mountain work and heavy grades only. Following is the data:

Type, 10-W; cylinders, 19 x 26 inches; driver diameter, 72 inches; total weight, 224,000 pounds; weight on drivers, 110,000 pounds; heating surface; tubes, 1,647.2 sq. ft.; fire box, 149.8 sq. ft.; total, 1,797 sq. ft.; grate area, 24.62 square feet; boiler pressure, 180 pounds; tubes: number, 202; diameter, $2\frac{1}{4}$ inches; length, 13 feet, $10\frac{1}{8}$ inches; fire box: width, 32 inches; length, 114 inches; type of boiler, Belpair; smallest ring of boiler, 60 inches; main journal: diameter, 8 inches; length, $9\frac{1}{2}$ inches;

valve: travel, $5\frac{1}{2}$ inches; lap, $\frac{1}{8}$ -inch; steam port: length, 19 inches; width, $1\frac{5}{8}$ inches; top of rail to center of boiler, 8 feet 1 inch.

Type, 10-W; tractive power per 116 M. E. P., 130.3; tractive power with M. E. P. 80 per cent. boiler pressure, 18,772; tractive power, per cent. weight on drivers, 17.65; grate area into heating surface, 72.94; cylinder volume cubic feet into heating surface, 210.9; cylinder volume cubic feet into grate area square feet, 2.88; revolutions required to run 60 miles per hour, 280; piston speed, feet per minute while running 60 miles per hour, 1,210.

PROFESSOR WM. F. M. GOSS (Purdue University): Mr. Street's paper summarizes in an excellent manner many of the important facts which seem now to define the characteristics of the high speed locomotive. I agree perfectly with what he says with reference to large wheel-diameters, and I believe that the limit has not yet been reached. Higher speeds should be reached by increasing the wheel diameter, rather than by increasing revolutions, for present practice gives a maximum speed of revolution which is already too high.

Referring to Mr. Street's remarks concerning cylinder proportions, I would like to add that there are at least two conditions likely to arise in the working out of a design, which justify lengthening the stroke. The first applies when the power and weight of the engine has so increased that the diameter of the axle and crank pin become so great as to leave an insufficient amount of metal between them in the crank casting, and the other appears when increased cylinder volume, if obtained by increasing the diameter, would introduce stresses which are difficult to meet in the design of reciprocating parts and in the frame. In either of these cases, lengthening the stroke gives relief. It increases the distance between the crank pin and the axle, thus affording a stronger crank casting, and, for a given cylinder volume, it reduces the value of the force transmitted by the piston and reciprocating parts, as well as that which must be resisted by the frame.

MR. MARSHALL: In reading the paper I had the same criticism to make of Mr. Street's remark about the short stroke engines, that has been already made by Professor Goss. It seems to me that in our modern passenger engines we are striving more and more every day to make the boiler as large as possible and to take the weight from the machinery. If we start with a 19 x 24-inch cylinder as a

basis, and desire to increase the power of the cylinders there are two ways of doing so—by increasing the diameter and by increasing the stroke ; if the diameter is not increased but the stroke is increased, then the strains, throughout the engine, caused by the steam pressure are not increased but the power is, and the result is that the cylinders weigh but little more, and the frames need to be no heavier; the rods, cross-heads, axles and every part of the machinery takes no more strain. If the increased power is obtained by increasing the diameter of the cylinders, then all these parts must be increased in size and weight, and less weight can be put in the boiler.

Now as far as counterbalance is concerned, if you use a short stroke you have greater weights to counterbalance ; if you have a longer stroke, the crank is further from the axle, the weights are less, and I think in the two cases which I have cited, the weight of the counterbalance will not be greatly different. For these reasons I think it is wise to consider the longer stroke.

There is another thing, which, of course, always comes up in a case of this kind, and that is the piston speed, and what effect it has upon the steam distribution : if the stroke is lengthened out to such an extent that the piston speed is excessive, I think it may have to be considered very carefully, but a slight increase in the piston speed, if unaccompanied by an increase in the revolutions per minute, is, in my opinion, not so serious as it might seem to be at first sight ; for while we have to consider piston speeds, I think that, within reasonable limits, the tendency to increase the stroke of the engine and keep down the diameter of the cylinder is all right.

Another point I would like to make in connection with Mr. Street's remarks on the Atlantic, and I presume it includes also the Columbia type, but I simply want to call your attention to this fact: If one has obtained the maximum power that is possible to any one locomotive of the 8-wheel type, and then attempts to get additional power either by going to a 10-wheel locomotive, or an engine of the Atlantic type, in other words, adding another pair of wheels, you immediately put onto the engine a weight of about 10,000 pounds that does not go into the boiler, and for high speed we want to put as much into the boiler as possible and want to keep the weight of the locomotive within reasonable limits. I think we want to get everything we can out of an 8-wheel locomotive before we add more weight in wheels, etc. I might say in this connection,

that the North-Western road has now under construction an 8-wheel locomotive that has a weight on the driver of 87,000 pounds, and the total weight of the locomotive is only about 136,000 pounds.

PROF. SMART: Mr. Street says, in the latter part of his paper, that he sees no reason why an increase in tractive power by lengthening the stroke, is better than a corresponding increase obtained by enlarging the diameter of the cylinder. In addition to the points brought out by Mr. Marshall, there is a point which has been developed in connection with our work at Purdue which seems to emphasize the fact that there are some good things in long stroke engines as compared with large diameter engines. Given two engines having equal cylinder volume and an equal striking distance between the extreme travel of the piston and the cylinder head, the engine having the longer stroke will be likely to have a smaller per cent. of clearance. It does not seem at first thought that a small additional per cent of clearance should make very much difference in the economy of the engine. For instance, an increase of from 10 to 13 per cent. in the clearance is only a small increase in volume, but it is an addition of 30 per cent. to the smaller clearance, and we have found quite recently a very striking falling off in the economy of the engine due to a slight increase in clearance. For that reason I think the effort should be to keep that quantity down to the smallest amount and that can be done more easily, other things being equal, with the long stroke engine than with the short stroke engine.

MR. E. E. RUSSELL TRATMAN: I notice that Mr. Street makes no reference to locomotives having a single pair of driving wheels. On the New York and Philadelphia service of the Philadelphia & Reading R. R.; one or two of these engines are in use, and have given good results. It was considered that as the 8-wheel engines could haul ten or twelve cars, while the express trains on this division required only four or five cars, that there was an excess of adhesion. After experiments with an 8-wheel engine with its side rods taken down and its counterbalances adjusted, the new engine was designed by Mr. Paxson, superintendent of motive power of the road, and Mr. Vauclain, of the Baldwin Locomotive Works. It is a 4-cylinder compound with Wootten firebox, and has cylinders 13x26 and 22x26 in.; two driving wheels, 7 ft. diameter; four truck wheels, 3 ft.; and two trailing wheels, 4 ft. 6 in. diameter.

The total weight is 115,000 lbs., of which 48,000 lbs. is on the driving wheels. It has hauled a train load of 380 tons for 85 miles at 40 miles per hour average speed, including eight stops, and is said to have attained 80 miles per hour with a train of five cars. There are grades of 26 to 36 feet per mile between Bound Brook and Wayne Junction, some of these being from three to five miles long. Some time ago I made a trip on this engine with Mr. Vauclain and timed speeds of 65, 72 and 75 miles per hour, with a train of three day cars and two sleeping cars. The return trip, with a train of six cars, was made with an 8-wheel Vauclain compound engine, weighing 123,800 pounds, with 88,000 pounds on the drivers, or nearly twice the adhesion of the other engine.

I think Mr. Street is rather hard on the 10-wheel type for fast service, their special advantage being for heavy trains which must be taken over steep and long grades at high speed. For instance, the Baltimore & Ohio R. R. engine, Fig. 16, with its 6½-foot wheels and adhesion weight of 113,000 pounds, appears to be well adapted to the conditions of service on that road. Such an engine is designed for this particular service, and can hardly be called an all-round engine.

It is interesting to note that motive power men are beginning to realize that similar conditions of service are not much affected by geography. It is not so very many years ago that discussion on the single-driver engine was usually disposed of by the remark that it was not adapted to American conditions, while in England the use of three pairs of coupled wheels for express passenger trains was derided, and even the truck was considered unnecessary under English conditions. We have already found the single-driver engine adapted to special conditions in this country, and in England even the most conservative roads are now using trucks on the engines and cars. A few years ago the Highland Ry., of Scotland, adopted 10-wheelers for its heavy fast trains, and now the North-western Ry., of England, is building some exceedingly powerful 10-wheelers in order to avoid the present necessity of double-heading the heavy express trains on the difficult portions of the line.

The difference between the Atlantic and Columbia types is that the Columbia engines have a pony-truck with large wheels, and the Atlantic engines have an ordinary 4-wheel truck. The latter type seems to be much preferred.

THE CHAIRMAN: Mr. Manchester, has the St. Paul any high speed engines?

MR. MANCHESTER: None; we just "get there" on time; that is all. Our high speed engines are all of the Atlantic type, and have been discussed somewhat in the other paper.

MR. STREET: In reply to what Mr. Tratman has said in calling attention to the single-driver engine, I say in the paper that the paper is not complete in any sense of the term; that it is merely the beginning of what might be made an extremely valuable record if the members of the Club thought it was of sufficient importance to establish such a record, and if it were made complete it should be revised and added to year by year. In preparing the paper I found several new things which are quite important in connection with the question of high speed passenger service, and the farther I got into the subject the more I was impressed with the fact that there was really very little on record in a practical form.

THE CHAIRMAN: I would like to ask Mr. Deems if he finds any economy in the piston valve for high speed?

MR. DEEMS: I think, Mr. Chairman, that I am not in a position to answer the question. We think that there is quite a little saving in the cost of repairs to the valve, but I have not had sufficient personal experience to say much about it. My attention was directed to a matter a few days ago; we put a dynamometer, so to speak, on the reverse lever of a box-valve engine carrying 180 pounds steam pressure, determined the pull under ordinary conditions of freight service, I should say rather favorable conditions, but assume that they were ordinary conditions, and then carrying the pull down to the eccentric blades, or at the links, and we found a pull of about 1,200 pounds. I am not prepared to say that that is all due to the friction of the eccentrics on the eccentric straps; there are other factors that enter into the calculations. The amount of friction surprised me. With the piston valve and 200 pounds steam pressure there is no difficulty at any time in lifting the latch of the reverse lever and holding the reverse lever with one hand. I think that in time we can have something more to say about the piston valve; we have not had it in use long enough yet.

THE CHAIRMAN: Has anyone else any remarks to make? If not, Mr. Street will make the closing remarks.

MR. STREET: In regard to the letter from Mr. Pattee, I would like to call attention to the fact that the statement is made in the paper that locomotive No. 12 could hardly be called a high speed passenger locomotive, and the main object in giving it was because it was the heaviest locomotive in passenger service.

With regard to the 10-wheel type, and the reference to the Baltimore & Ohio engine: I think it is very significant that this engine has 78-inch drivers and is the only 10-wheel locomotive in the list; I think the large drivers play an important part in the success of the 10-wheel engine on the Baltimore & Ohio road. With a 10-wheel engine in passenger service, a comparatively small driver is used; but you will notice with the Columbia and Atlantic types of locomotives all have large drivers, in fact, the largest driver shown in the table is on a Columbia type locomotive.

In regard to the question of the stroke, as referred to by Mr. Marshall and Prof. Smart, I was referring only to radical changes; my intention was to refer to radical changes in that direction, and while Mr. Marshall and Prof. Goss are both correct in saying that the strains due to the steam pressure are increased by enlarging the diameter of the cylinder, nevertheless, the revolving strains and the rack and slam-banging of the engine is increased by the increase of stroke. It is an easy matter to figure the increase of strains due to the increase in the diameter of the cylinder, but when you come to figure the strains due to hard riding of the engine it is another matter.

In regard to the steam distribution referred to by Professor Smart: While running at high speeds the valve travel is so short that the variation referred to would amount to very little, if anything. What he says in regard to clearance is true. The percentage of clearance would be greater, if the diameter of the cylinder were increased, than if the stroke were increased. I agree entirely with Mr. Marshall in regard to the 8-wheel locomotive, that the greatest power possible should be obtained from the 8-wheel locomotive before an additional pair of wheels is used, but a great many of the roads are finding that they cannot get sufficient boiler capacity on two pairs of drivers.

In regard to piston valve: I think that the record made by the C. B. & Q. engine No. 4, Atlantic type, is worthy of considerable attention. It made a run from Burlington to the Union depot,

Chicago, a distance of 205.8 miles, at an average running speed of 61.8 miles per hour, with a train of four cars.

Adjourned.

THE DAVID L. BARNES LIBRARY.

SPECIAL NOTICE! The David L. Barnes Library of this Club, at 1750 The Monadnock, Chicago, is open for the use of members and their friends, and we hope it will be used freely. It is open on week days from 9 a. m. to 5:30 p. m., except on Saturday, until 3 p. m. Books must not be removed from the Library, but the librarian will assist visitors in finding information and will promptly reply to letters from out-of-town members desiring information from the Library. Donations of books and technical publications will be gratefully received.

TRUSTEES OF THE LIBRARY.

List of duplicate copies of the Proceedings of the Western Railway Club which are in the David L. Barnes Library and are for sale or exchange:

1888—Sept. and Oct. (bound in one).

1889—Oct., Dec.

1890—Feb., Sept., Oct., Nov., Dec.

1891—Jan., Mar., Apr., May, Oct., Nov.

1892—Jan., Feb., Apr., May, Sept., Nov., Dec.

1893—Two complete volumes; also single copies of Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

1894—Jan., Mar., Apr., May, Oct., and Index of subjects discussed by the Club.

1895—Jan., Apr., Sept., Oct., Nov., Dec.

1896—One complete volume, also single copies of Jan., Mar., May, Sept., Nov., Dec.

1897—Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec., also two complete volumes.

1898—Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

Correspondence relating to the Library, donations of books, periodicals, etc., for the files, or duplicates sent for exchange should be addressed to H. de K. Woods, Librarian, 1750 Monadnock, Chicago.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED, April, 1884.

INCORPORATED, March, 1897

APRIL 25, 1899.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 8.

CHICAGO, ILL.

{ \$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

Directors:

H. G. HETZLER,
Supt. Fght. Terminals, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER. JOHN W. CLOUD.
F. W. BRAZIER. H. G. HETZLER.
PETER H. PECK. F. W. SARGENT
PROF. WM. F. M. GOSS.

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman.
WILLIAM FORSYTH,
Aurora, Ill.
A. M. WAITT,
New York City.

The regular monthly meeting of the Western Railway Club was called to order at 2 p. m., Tuesday, April 18, 1899, in the Auditorium Hotel, Chicago. President C. A. Schroyer in the chair.

Following are the names of those who registered:

Allcott, A. E.	Gollmar, Geo. J.	Peck, P. H.
Ball, H. F.	Graham, J. A.	Pettis, C. D.
Bischoff, G. A.	Grieb, Jos. C.	Rennolds, Wm. C.
Brazier, F. W.	Groobey, Geo.	Robinson, Jay G.
Bryant, W. E.	Hatswell, T. J.	Sanborn, J. G.
Buker, J.	Hatswell, Jr., T	Sawyer, Edw. C.
Cardwell, J. R.	Hennessey, J. J.	Scales, R. P.
Clifford, C. J.	Hill, Jas. W.	Schroyer, C. A.
Coleman, J.	Jacoby, W. L.	Shea, R. T.
Conger, C. B.	Johann, Jacob.	Stinard, F. A.
Cooke, W. J.	Kirby, T. B.	Smith, H. E.
Crosman, W. D.	Kuhlman, H. V.	Smith, R. D.
Cushing, Geo. W.	Lowell, W. W.	Toppa, J. S.
De Remer, W. L.	Mann, Horace.	Tratman, E. E. Russell.
Drake, Edw. A.	MacKenzie, John.	Whyte, F. M.
Eames, Ed. J.	Manchester, A. E.	Wickhorst, M. H.
Fildes, Thos.	Mileham, C. M.	Wood, G. S.
Giroux, G.	Morris, A. D.	Woods, E. S.
Goehrs, Wm. H.	Morris, T. R.	

THE PRESIDENT: The minutes of the March meeting have been printed in the Proceedings and unless an objection is offered they will stand approved as printed. Hearing no objection, they are so approved.

The Secretary will now read the names of the applicants for membership whose applications were approved by the Directors at their meeting this morning.

The Secretary then read the following names:

Mr. W. S. Adams, F. W. Bird & Son, Chicago.
 Mr. Thos. E. Bolton, Consulting Mechanical Engineer, 21 River St., Chicago
 Mr. F. O. Brazier, Agt. Lappin Brake Shoe Co., Chicago.
 Mr. J. J. Brisbin, Midvale Steel Co., Chicago.
 Mr. Otto W. Buenting, 22 College Av., W. LaFayette, Ind.
 Mr. J. F. Dunn, S. M. P., Oregon Short Line, Salt Lake City, Utah.
 Mr. Robt. L. Gordon, Pressed Steel Car Co., Chicago.
 Mr. Horace Mann, Div. M. M., F. & P. M., Port Huron, Mich.
 Mr. H. N. May, Train Master, P. C. C. St. L. Ry., Logansport, Ind.
 Mr. Chas. McCann, Jr., 1618 Stiles St., Philadelphia, Pa.
 Mr. H. C. Nutt, Supt., B. & M. R. R. in Neb., Sheridan, Wyo.
 Mr. Don Sweeney, Draftsman, C. B. & Q. R. R., Chicago.
 Mr. Chas. H. Taylor, Diamond Rubber Co., Chicago.
 Mr. John Oliver Williams, Manager, Magnolia Metal Co., Chicago

THE PRESIDENT: The next order of business of which there is any needing attention is new business; we may not have another opportunity so favorable as this to hear a letter from Mr. Cloud, and the Secretary will read it to us.

NO. 774 ROOKERY BUILDING, CHICAGO, April 5, 1899.

F. M. Whyte, Esq., Secretary Western Railway Club.

DEAR SIR—I wish to resign the Treasurership of the Western Railway Club, and I will be glad if you will have some one named to whom I can turn over the bank account not later than the date of the next meeting, viz., April 18th.

Yours truly,

JNO. W. CLOUD, Treasurer.

THE PRESIDENT: I presume it is generally known that Mr. Cloud is going to leave us, and has resigned his position as Secretary of the Master Mechanics and Master Car Builders' associations, as well as Treasurer of this Club. The action taken by the Board today on this letter was to accept the resignation, to express to Mr. Cloud regrets at his leaving us, and Mr. Whyte has been appointed to receive and disburse the funds of the Club until such time as another treasurer is elected. If this does not meet with the approval of the Club we shall be glad to hear from you. You all realize that Mr. Cloud has been a member of the Club for a number of years, has been a hard worker and a faithful attendant, and I believe that I voice the unanimous sentiments of the members in expressing sincere regrets that it is necessary for him to resign as an officer.

There is a communication from Dr. F. W. Gunsaulus, President of Armour Institute of Technology, which the Secretary will read.

The Secretary then read the following letter:

ARMOUR INSTITUTE OF TECHNOLOGY, April 12, 1899.

Mr. F. M. Whyte, Secretary Western Railway Club.

MY DEAR SIR—I understand that you are to hold a meeting of your Club on Tuesday, April 18th, and I take pleasure in offering you the use of our Science Hall, in the Armour Institute of Technology, for that meeting. I hope that you may be able to accept this invitation, and at the same time view the work that we are doing here. Anything that we can do to make your meeting a pleasant occasion, we will be glad to do. Will you kindly indicate at your earliest convenience whether your Club will be with us at that time? Awaiting your favorable reply, I am,

Yours truly,

F. W. GUNSAULUS.

THE SECRETARY: I replied to the letter that the notices were already out calling for the meeting in the Auditorium, and that, no doubt, the Club would be pleased to accept the invitation for some other month.

THE PRESIDENT: The Board of Directors received this communication and instructed the Secretary to acknowledge it, expressing our regrets at our inability to accept the very kind invitation this spring, but that we would be glad to avail ourselves of the opportunity of meeting at the Armour Institute at some meeting in the fall; we thought that it would not be wise to meet there in May, because that will be the last meeting of the year and the annual election of officers occurs then.

The next order of business is the report of the committee on M. C. B. couplers, of which Mr. Delano is chairman, and he will please read the report.

Mr. Delano read the report of the committee, as follows:

REPORT ON M. C. B. COUPLERS.

TO THE WESTERN RAILWAY CLUB:

In a paper presented by Mr. Peter H. Peck to the Western Railway Club at the October, 1898, meeting entitled, "The Adoption of a Standard Knuckle," attention was drawn to the enormous expense to the railroads of this country, arising from the multiplicity of the M. C. B. couplers and to the necessity entailed on railroads of keeping a large supply of extra knuckles on hand for emergencies or repairs, indicating clearly the great desirability, either of having fewer couplers or an interchangeable knuckle. Certainly, Mr. Peck recognized that to adopt a uniform or interchangeable knuckle was impracticable, and that to specify the use of a uniform or standard knuckle was tantamount to requiring the adoption of a uniform or standard coupler. Your committee regard any such attempt, however desirable, as wholly impossible, and look for an improvement in the present mixed conditions through the operation of the law of evolution, which shall, as time goes on, weed out the weak and objectionable and allow the fittest to survive. Indeed, there is strong evidence that this is already taking place.

Your committee further believes that this process of evolution can be hastened by an intelligent investigation of the situation; by specifications requiring accuracy of contour lines and good material; and by careful records of coupler failures in service. As has been already pointed out in our discussions of this matter, M. C. B. couplers have heretofore been regarded as of sufficiently equal merit to allow the matter of choice, at least with many railroads, to depend largely, if not wholly, on the price quoted.

In the preliminary reports of this committee a list of the couplers in use has been given, and from that it will be seen that there have been in use on railroads of the United States upwards of 100 different M. C. B. couplers. Of this number certainly not more than ten or twelve are likely to long remain standard couplers. The other ninety must fall by the wayside for defects which have developed in service.

From the mass of suggestions and information which your committee has received, it offers the following general recommendations:

1st. Railway companies should purchase couplers on specifications requiring:

(a) Accurate agreement with M. C. B. contour lines. [*By this is meant, not simply that the limit gauge may be introduced, but that the lines of the coupler shall coincide with the M. C. B. lines when referred to the center line of the shank produced. See Fig. 2.*]

Specifications and Tests.

(b) Couplers must be made to withstand shock and a fair proportion of all purchased should be tested under a drop test.

(c) Couplers must be strong in tension and a proportion of them should be tested under tension.

2nd. It is thought by your committee that the length of guard arm should be specified by carrying the M. C. B. contour lines about $\frac{3}{4}$ of an inch further than at present, [see Figs. 2 and 3] modifying the present M. C. B. limit gauge, as shown in Figure 1. *[In this figure is also shown the center line marked on the gauge and further located by center pin or post holes as a means of attachment to a supplementary gauge to be clamped on the coupler shank.]* N. B. There would be a further improvement, if the radius of the curve at the point of the guard arm was specified to be not less than 3-16 of an inch.

Guard Arm.

3rd. Your committee wishes to dwell upon the importance of service records of couplers and feels that there is nothing that will so soon point out the defects in apparently meritorious devices. At the present time there is no good data on the comparative wear of couplers and this important feature of the question can only be determined by the most accurate service records. The interchange of cars makes the defect of every coupler a matter of concern to every railroad company. No railroad company can afford to neglect this question, because it is itself purchasing a satisfactory coupler.

Service Records.

4th. The question of the location of the pivot pin hole and suggestions looking to greater accuracy in forming this hole, so as to avoid much lost motion is certainly an important consideration, but your committee is not prepared at this time to offer a recommendation upon it.

Pivot-Pin Hole.

5th. Your committee is impressed with the necessity of a positive locking device, one which will not allow the locking pin or block to "jump" or "crawl" and so permit cars to become uncoupled. Notwithstanding this, however, your committee has no recommendation to make, except to state that no such device, however meritorious it may seem, should be adopted, until after a very thorough service test. It has already been proved that some of these apparently "positive locks" have proved worse than useless and, in some cases even, very objectionable.

Positive Locks.

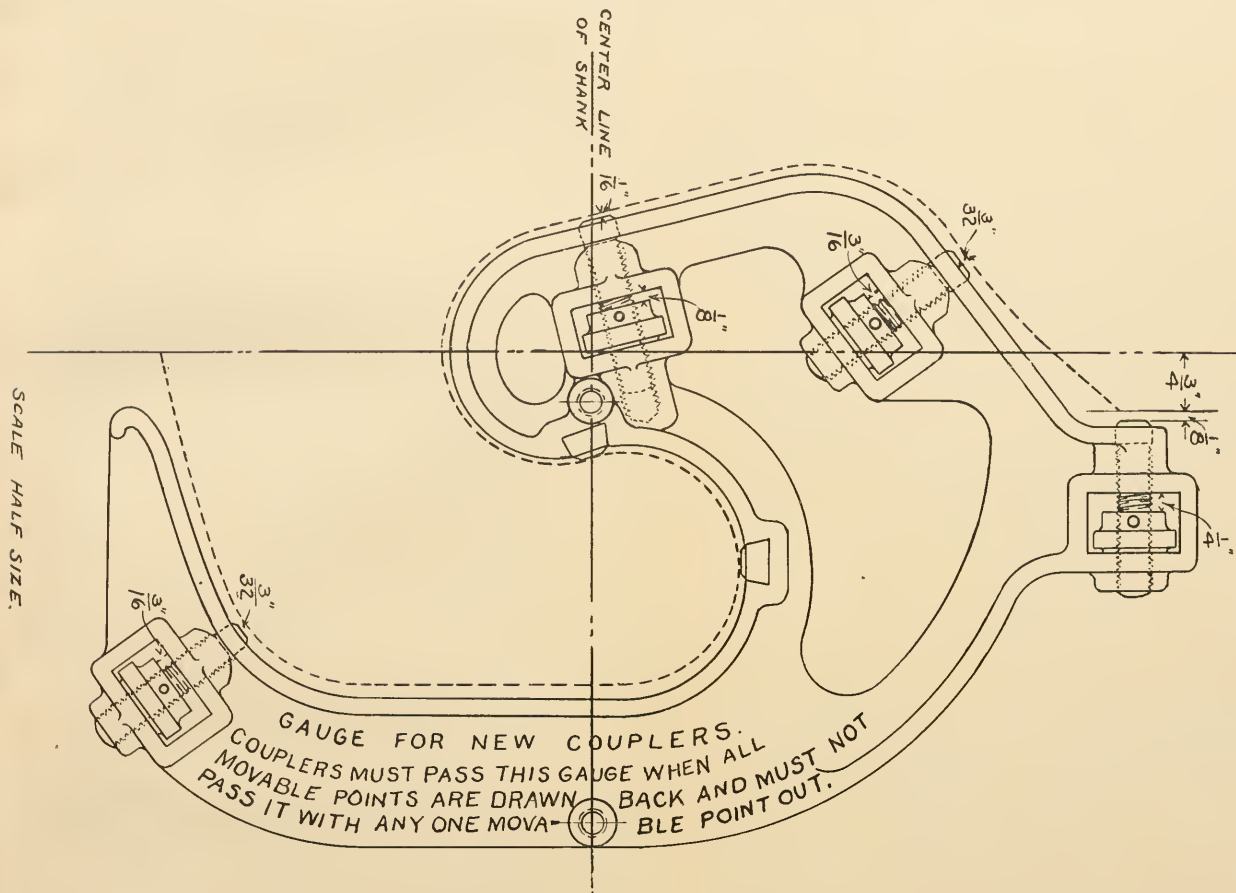
6th. The method of uncoupling is one which deserves consideration and which in the opinion of your committee is susceptible of improvement. There can be no question but that "break-in-twos" have frequently occurred in service from the uncoupling devices now in use. The most familiar way of lifting the locking pin or lock block is by a chain and tumbling shaft fastened to the end sill or deadwood. In case the coupler drawbar pulls out beyond a certain point, the pin or lock block is raised or withdrawn and the car becomes uncoupled. That there are other objections to at least some of the devices designed to take the place of the chain and tumbling shaft are admitted and your committee does not feel prepared to make any recommendations on this point, further than to call attention to its importance.

Uncoupling Devices.

7th. Some couplers are furnished with what is called a lock-set. This is a very desirable thing in switching cars and we might say essential to the perfect coupler, yet it should be borne in mind that in adding any complication to the coupler there should be a very careful investigation of its operation in service.

Lock Set.

Figure 1. M. C. B. Limit Gauge, amended to give guard arm limit, also with center pin or post holes on line of shank for attachment of supplementary gauge.



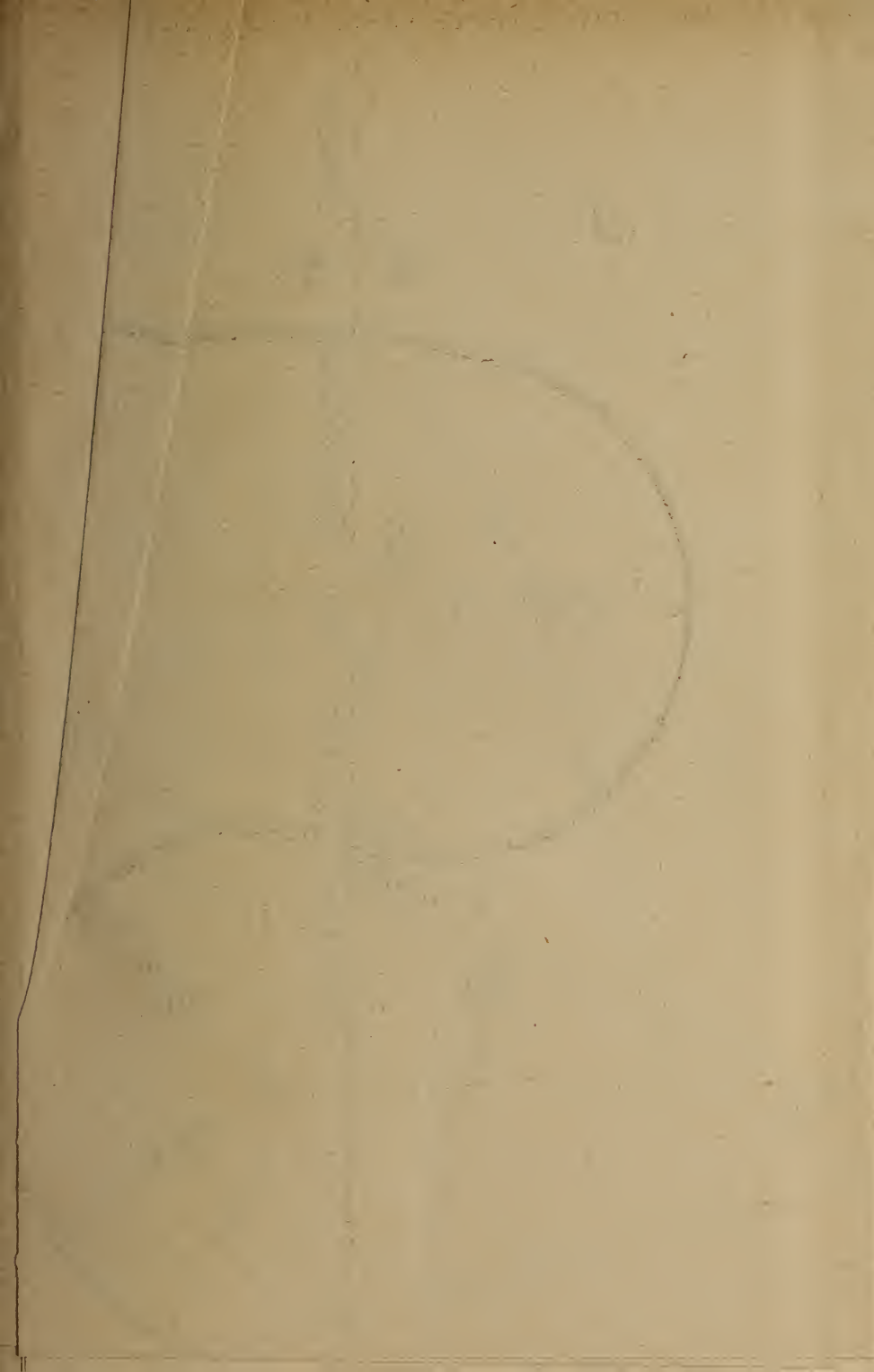
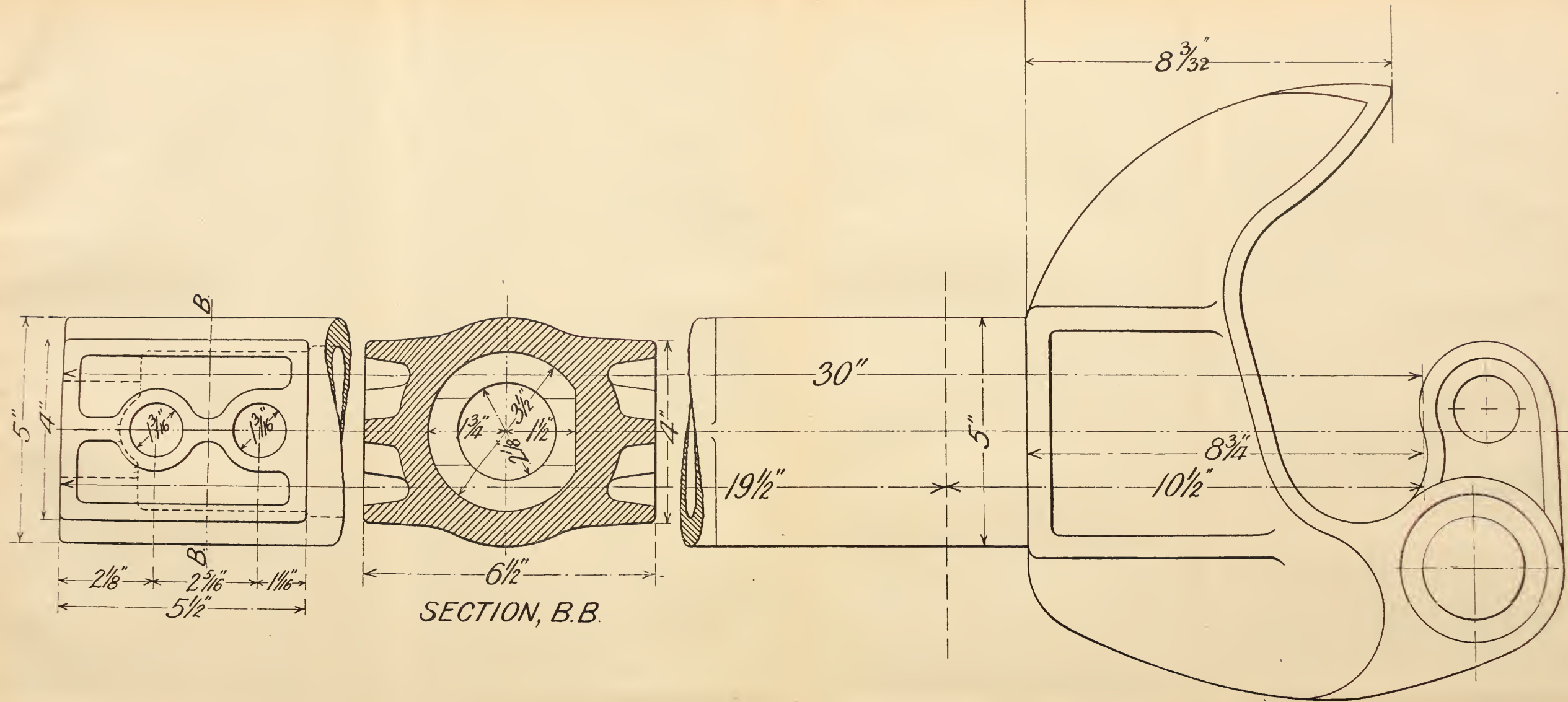




Figure 3. M. C. B. Coupler drawing amended to give dimensions of guard arm.



The criticism which has been made that M. C. B. couplers, instead of being automatic couplers, are automatic *un*-couplers, has arisen almost entirely from the defects introduced by attempting to devise a satisfactory lock-set.

8th. On the general question of M. C. B. couplers, your committee desires to put itself on record as believing that the lines of the M. C. B. Committee will prove entirely satisfactory, and that there is no necessity for a divergence from them. As already stated, the length of the guard arm should be produced somewhat and the relation of the contour lines to the center line of the shank should be adhered to strictly.

**M. C. B.
Contour
Lines.**

Your committee understands that the Committee of the M. C. B. Association has already designed a gauge which can be slipped over the shank of the coupler and so fix absolutely the relation of the center line of shank to the contour line, as contemplated in the M. C. B. lines as shown in Fig. 2, and your committee urges very strongly that such a gauge be adopted.

In the main, there can be no question but that the M. C. B. coupler has proved immensely superior to the link and pin coupler, and what is needed more than anything else is an insistence on a compliance with the M. C. B. contour lines, and rigid requirements as to strength.

F. A. DELANO, <i>Chairman.</i>	} <i>Comm ttee.</i>
J. N. BARR,	
THOS. FILDES,	
JOHN MACKENZIE,	
PETER H. PECK.	

THE PRESIDENT: Mr. Delano will please open the discussion on the report.

MR. DELANO: I want to explain why the committee did not recommend a gauge. In the first place, there is a committee of the M. C. B. Association working on this subject, Mr. Atterbury's committee, and that committee has already designed a very good gauge. In addition to this, it occurred to the committee that there were several ways of accomplishing the result, and one of these ways was to make a gauge which could be attached to the old limit gauge. That is, as it would make a rather long and clumsy gauge, it was thought that something that could be attached to or detached from the limit gauge would be a good thing. Also, two members of the committee, from whom I hope we will hear, have gauges of their own design to show you.

The committee had some cardboard templets made from actual new couplers. We were in hopes of illustrating these in the minutes, but it seems to me to be a very difficult thing to do, but anybody can readily understand from these templets, and I will leave the templets on the table for the information of the members here who

may be interested, to see for themselves what a very wide variation in contour lines there is. Here is a case in point, Coupler No. 14. I think, perhaps, I can show, by placing the red center line of this coupler (indicating) on the center line of the M. C. B. contour line; you will see quite a big variation. Now that variation looks as if the M. C. B. limit gauge could not be introduced; but when you rotate this templet in this position, you will see that it comes pretty close to the M. C. B. limit gauge; but look at the two center lines; here is the center line of the M. C. B. contour lines, and here is the center line of the coupler; they are at an angle to each other, diverging at the stop-shoulder by about $\frac{3}{4}$ -inch. (Explaining further by means of the cardboard templates under a tracing showing M. C. B. contour lines.)

This divergence has not been entirely due to the changing of the lines; at first I thought that different manufacturers had adopted their own lines, but in some cases it is pretty clear that the difference is due to unequal shrinkage or bending of the coupler head; and I think that coupler manufacturers, if they appreciate this, will be a little more careful and will not pull the couplers out of the molds while the metal is still in a plastic condition, or else will so distribute the metal as to make the couplers shrink more evenly.

Another thing that I think will be of interest to the members is illustrated by these blue prints. These two blue prints show the relation of the guard arm to the contour line, and also the relation of the "stop-shoulder" to the contour line. That is quite an important point, especially as we are fitting up cars with dead woods, the relation of the contour lines to the stop-shoulder must be the same, it cannot vary much; at the same time the relation of guard arm should be fixed, and this, you will notice, the committee has done in Figs. 2 and 3.

The variation in the length of the guard arm, not only in its relation to the M. C. B. contour lines, but in its relation to the stop-shoulder is shown in these prints which I have marked Exhibits "A" and "B." The distance from the stop-shoulder to the point of guard arm is recommended by your committee in its report to be not less than $8\frac{3}{32}$ inches. (See Fig. 3.) The following table shows the actual distance measured on seven prominent couplers:

Exhibit "A."

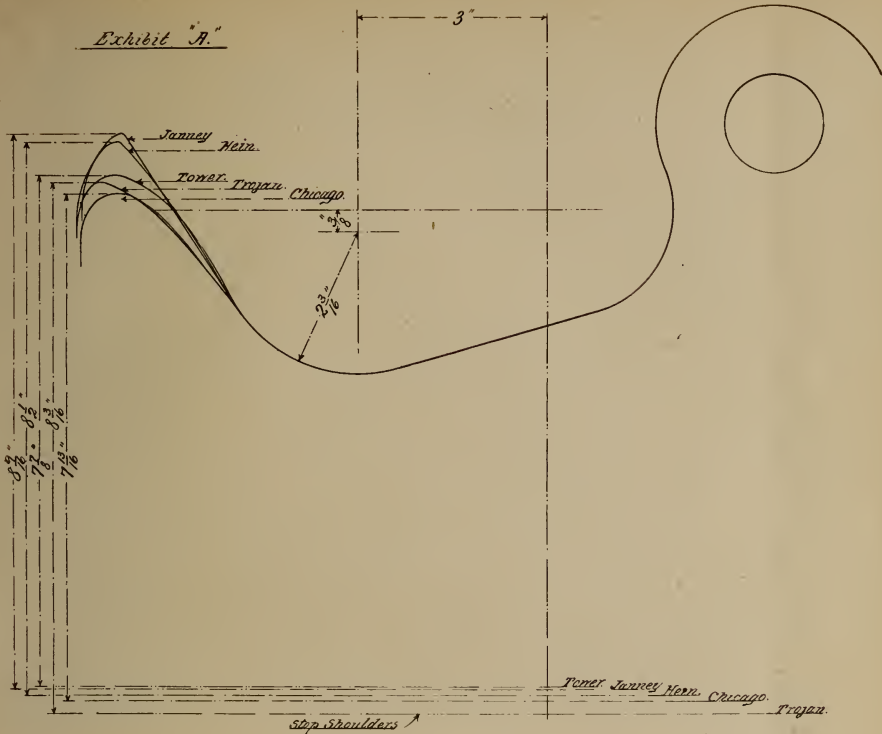
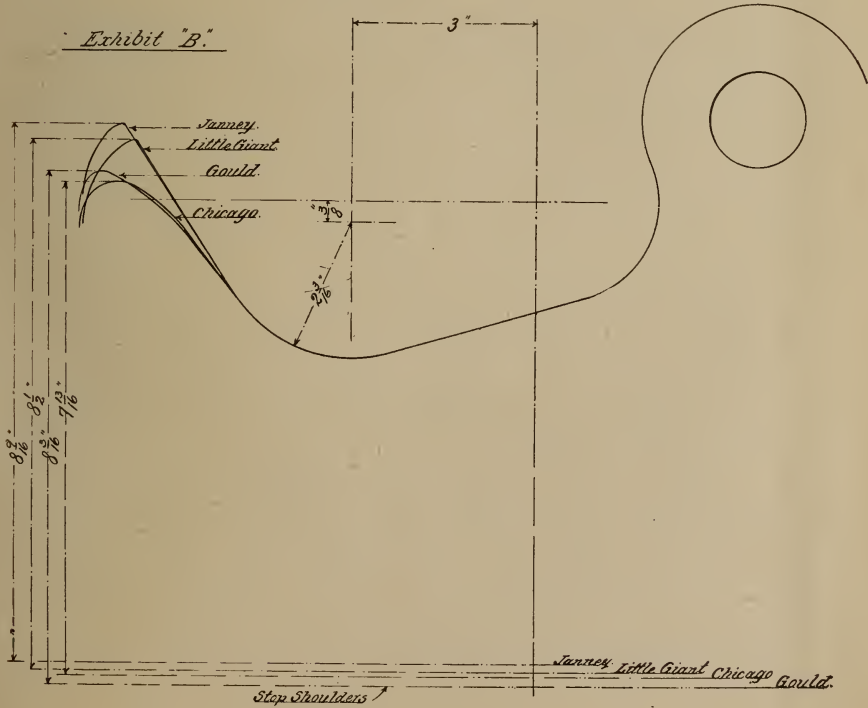


Exhibit "B."



Janney	$8\frac{9}{16}$ inches.
Hien	$8\frac{1}{2}$ "
Buckeye	$8\frac{1}{2}$ "
Trojan	$8\frac{3}{16}$ "
Gould	$8\frac{3}{16}$ "
Tower	$7\frac{7}{8}$ "
Chicago	$7\frac{13}{16}$ "

Mr. Barr has made one point, and the committee perhaps did not make it as prominent as they ought to do, though it is mentioned in the second recommendation, namely, the radius of this point of the guard arm here (indicating). It is perfectly obvious that you can carry that guard arm out here pretty far, but if it comes at a sharp point, the point will soon be battered back, and it will be no more effective than if it were shorter. There is much variation in the form of this contour, and the committee recommends that that point should be turned with a radius of about $\frac{3}{16}$ -inch.

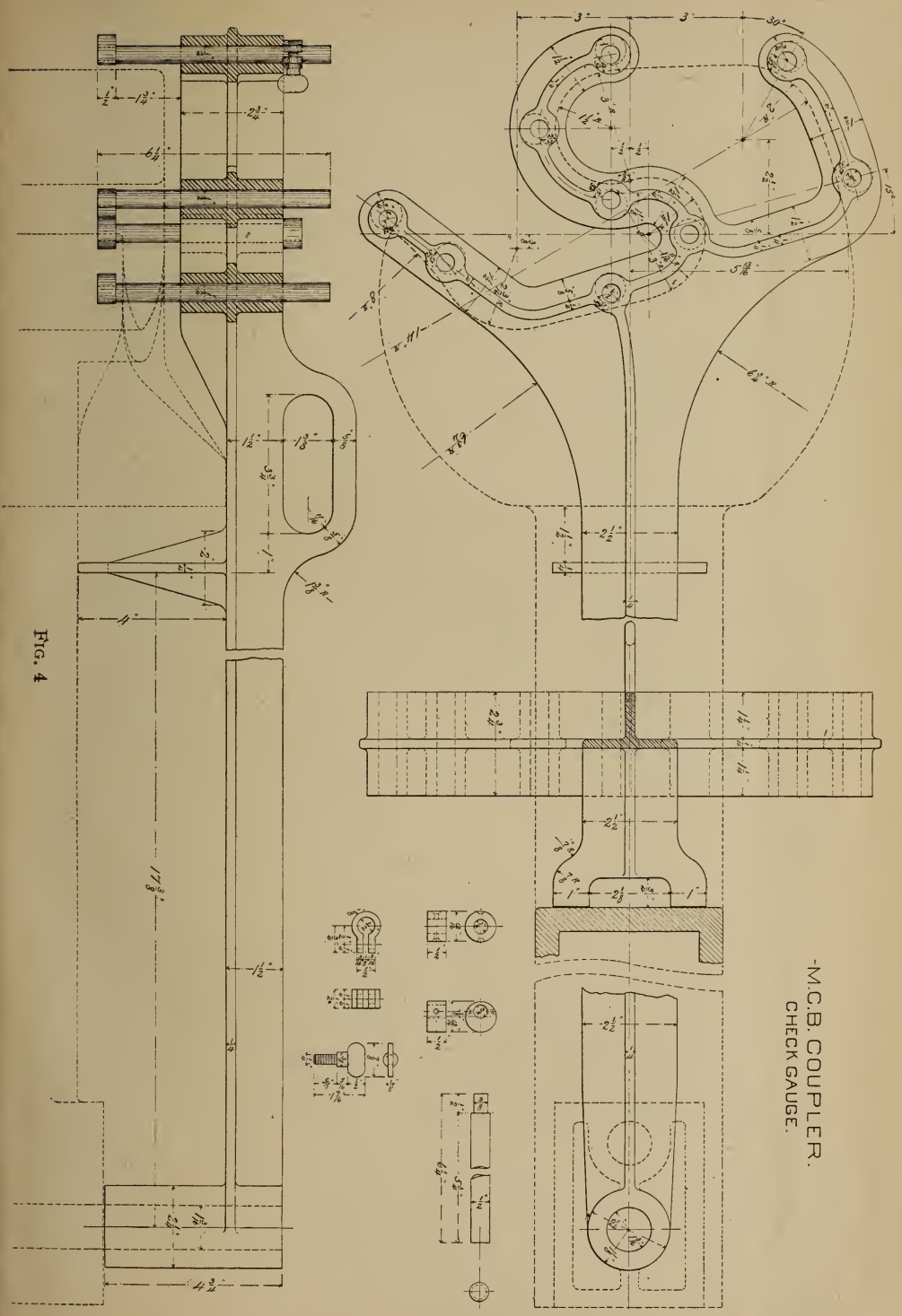
I would like to have Mr. Barr exhibit the blue print of a gauge that he has designed, to fix the relation of the contour lines to the center lines.

MR. J. N. BARR (C., M. & St. P. Ry.): Gentlemen, I thought that the discussion of gauges for M. C. B. couplers would not come up today, and I am beginning to feel quite strongly that the gauges which we have in use do not meet requirements. We have some couplers at Milwaukee now that are not in proper shape and will not couple when placed in cars, but the gauges do not reveal the trouble. Whether the gauge which I propose, and which is represented by this blue print, Fig. 4, will detect the trouble or not, I do not know, but I am inclined to think that it will do more in this direction than any gauge with which I am familiar. The manipulation of the gauge will be understood from the illustration.

At the request of the President, Mr. Thos. Fildes (L. S. & M. S. Ry.) exhibited a drawing of a gauge, and explained the idea underlying same (see Fig. 5).

MR. FILDES: For convenience I have lettered the various parts as follows: The sliding gauge nearest to the guard arm I have called "A," the other "B." The hinged caliper arm "C," the clamps "D," the main body "E." The two pins for locating the body $\frac{1}{2}$ inch back of the horn and 1 inch above the shank are "F" and "F1" and the part inside of the contour line on which the mov-

M.C.B. COUPLER.
CHECK GAUGE.



able parts are fastened "G." The gauge is placed on the coupler with the pin "F" and lug at rear resting on the shank and pin "F" against the horn. The clamp "D" is then adjusted and fastened by the thumb-nut. The slides "A" and "B" are then pushed out to their extreme limit in which position they should just engage the face of coupler, if contour line is properly located. The caliper arm is for determining the length of the guard arm and is shown with the proposed $\frac{3}{4}$ inch extension on the guard arm. The length of this caliper and the spacing of the gauge marks cannot be established until the distance of the guard arm from the center line of coupler is decided on. The gauge marks when made will represent $\frac{1}{8}$ inch travel at guard arm.

THE PRESIDENT: As I understand it, the object of the gauges, drawings of which are exhibited, is by their use to determine whether a line drawn through the contour lines of the M. C. B. coupler is exactly at right angles with the draft line. You understand, of course, that the contour lines of the head may be correct according to the gauge, and yet, as the result of unequal shrinkage in the walls of the stem of the bar, such unequal shrinkage may throw the entire head around sufficiently to prevent coupling. That has been found in actual practice, and Mr. Barr expects that the gauge which he has made will locate such trouble with the coupler. The M. C. B. Association has never taken any action on a gauge of this kind, or on any other scheme of determining when the head stands at right angles with the stem or the center line of draft. Now we have some coupler manufacturers in the room who probably may want to say something on this subject; if so, we will be glad to hear from them.

MR. JAMES TIMMS (Buckeye M. I. & C. Co.): Mr. President, I would ask Mr. Barr how much clearance he would allow in the gauge which gives the distance between the gib or bracket and the first rivet hole in the end of the shank. I have had occasion to measure several couplers made by one of the leading manufacturers, and I find there is a variation of $\frac{3}{8}$ to $\frac{1}{4}$ -inch. I presume this is caused by the expansion and contraction in the metal before and after annealing.

MR. BARR: That would have to be agreed on.

MR. TIMMS: I thought that you might have some recommendation to make as to what clearance should be allowed.

MR. BARR: That is something on which no limit is fixed.

THE PRESIDENT: As a manufacturer have you ever encountered this question in putting your bars on the market?

MR. TIMMS: No, sir. Never heard of any complaint. In regard to the cardboard templets, as presented by Mr. Delano, showing the variation of the different couplers from the M. C. B. contour, I can hardly see how he could get the exact contour without a gage which would gauge the shank as well as the head, so as to establish the center draft line and also the cross section line, which establishes the length of the guard arm. I find that the cardboard templets referred to, do not show this cross section line, therefore, I do not see how the variation in the contour could be fully demonstrated.

MR. TOBEY: I do not think Mr. Timm's point is well taken, because Mr. Barr's gauge would not be the less effective, even if the stop-shoulder were not marked on the gauge; it fits over the side of the shank and is not limited by the stop-shoulder at all. The distance from the rivet hole to the stop-shoulder does not make the contour line.

MR. BARR: I was going to say that from my experience with our gauges I can not find out what is the matter with the couplers to which I referred, and for that reason I do not believe our gages are practically what we expect they are. There is something else needed. It may be that those couplers are twisted so that they strike in such a way that they do not enter far enough to couple. I do not know. And it is a very difficult matter to find out just exactly, by any measurements, whether the contour lines are in their proper direction relative to the center of the coupler. With this gauge that will be definitely demonstrated, and I think too, that one of the most important points in all gages is to have them fixed so that the guard arms touch at the same time. If they do not strike in that way when the cars come together, one guard arm must receive the full force of the blow. If they both touch at the same time, then both guard arms receive and distribute the blow and the blow on the guard arm is only half as great. I have no doubt that the coupler manufacturers have recognized that point and found it was a great saving to guard arms on their own couplers to follow such a practice. It may be a saving to some of the guard arms, but it is a big expense to the company, because any variation in the length of guard arms, if it is sufficient to keep one from contact, doubles the force of the

blow on the other guard arm and railroads should not tolerate this at all. As Mr. Delano has said, the radius of curvature of point of guard arm ought to be such that all couplers are put on exactly the same basis in that respect.

MR. W. S. MORRIS (C. & O. Ry.): The question of distance of the end of the guard arm to the shoulder bracket, I consider is one of the most important in the coupler. In seven couplers, the chairman of the committee stated, there was a difference of from $7\frac{1}{8}$ to $8\frac{9}{16}$ inches. Mr. Barr has just explained the difficulty of breakages that will occur from variation in guard arms; there is still a further difficulty that I think should have some attention and that is, the life of the coupler will not be as great with the shorter guard arm as it will be with the longer guard arm. Now, the coupler committee of the M. C. B. association on couplers will make a recommendation for a greater length of guard arm than this committee has done. There is a variation as great as $\frac{1}{2}$ -inch, and I would like to ask the committee, or the chairman, if, in his investigation, he has determined why these guard arms have been made short? What is the reason for it?

MR. DELANO: I will say for Mr. Morris' benefit that there have been several reports of progress by this committee, and in them we have taken the position that the reason the guard arms have been made short was to keep them out of harm's way. This point is brought out by Mr. Barr. I think that unless this length is actually specified by the M. C. B. association, you can hardly blame the manufacturer for wanting to make his coupler so that it will not break. Some other coupler might break but not his coupler.

MR. G. W. RHODES (B. & M. in Neb.): Mr. Chairman, in this report I notice the committee lays a great deal of stress on the importance of having tests, and they say couplers must be made to withstand shock and a fair proportion of all purchased should be tested under a drop test. By couplers, I do not understand they mean simply the drawbar, they mean the knuckle as well as the drawbar. The question that has just been asked is, why the guard arm is made so short, and it would look as though the answer is a reasonable one, viz., to avoid punishment. I want to give the coupler manufacturers a pointer on something that will give additional strength without causing any serious additional cost. It is not only the guard arm that breaks, but the knuckles break—in fact,

if you go around the scrap yards you will find by far the greater proportion of the breakages in the knuckles. I am afraid that so long as the railroad companies will submit to broken knuckles, the manufacturers will continue to make the kind that break and let the railroad companies buy knuckles at replacement prices. I believe that they will not be our best friends unless we mildly object to the kind of knuckles they sell to us, and what I would propose as a question for the railroad men to ask themselves and the coupler men to answer is, why do knuckles have such a large opening between the top and the bottom lugs? I think I have seen them with $2\frac{1}{8}$ -inch openings and quite a good many are 2 inches. What is the necessity of a 2-inch opening in a knuckle that is already weak? If I am correctly informed, some of the railroad men have been asked by, or have asked, the M. C. B. committee to recommend a solid knuckle.

THE PRESIDENT: You refer to the opening for the link?

MR. RHODES: Yes, the link opening. Of course, a solid knuckle at the present time is hardly to be considered. There must be an opening between the knuckle lugs; but the question that I would like to ask is; why have a $2\frac{1}{8}$ -inch opening in the knuckle?

Some time ago we had fifty knuckles cast, and we have them now; we made the opening $1\frac{1}{2}$ -inch, and we took the knuckles and distributed them on seven divisions of the C. B. & Q., putting them on way cars, so that they might meet the worst trouble of any coupler—if there are any links and pins left on a train, they are placed at the rear end; if there is any pushing out of yards by extra engines, it is at the rear end—and have not had a solitary complaint from any of those fifty knuckles. While we are considering the question of strengthening drawbars for preventing breakages, it seems to me here is a capital opportunity to strengthen the knuckle. There is no reason why the link opening should be greater than $1\frac{3}{4}$ inches, but I believe that so long as railroad people will buy these knuckles, the manufacturers will continue making such knuckles. The idea in making the opening $1\frac{3}{4}$ inches is to admit the D section link. The ends of the D section are upset and are wider than the sides; the sides will always enter a $1\frac{1}{2}$ -inch knuckle opening. Train men soon discover this way of inserting coupling links.

MR. BARR: Mr. President, I make a motion that Mr. Timms give the meeting his ideas about contour lines.

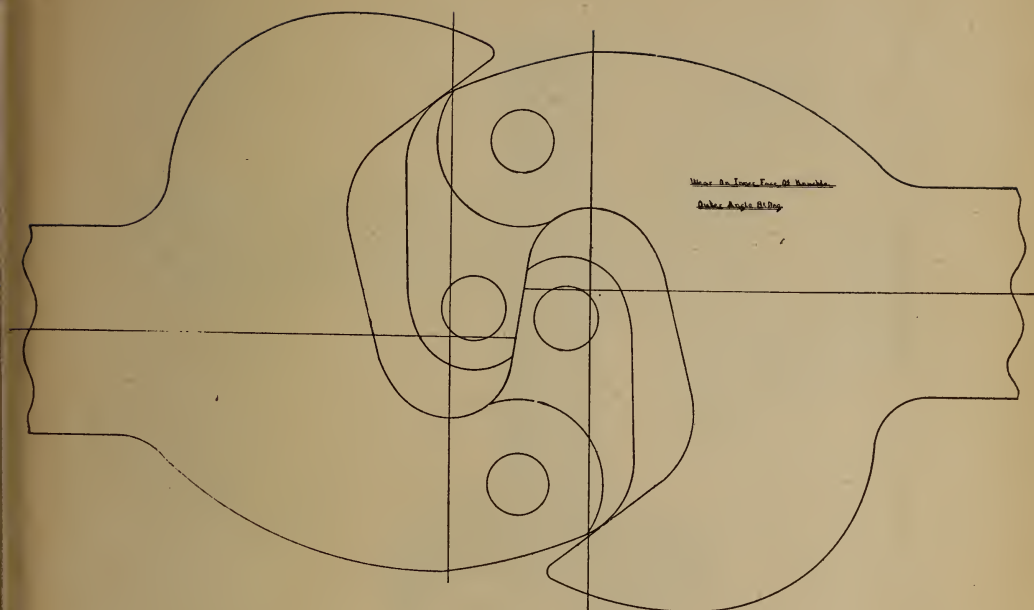


FIG. 6

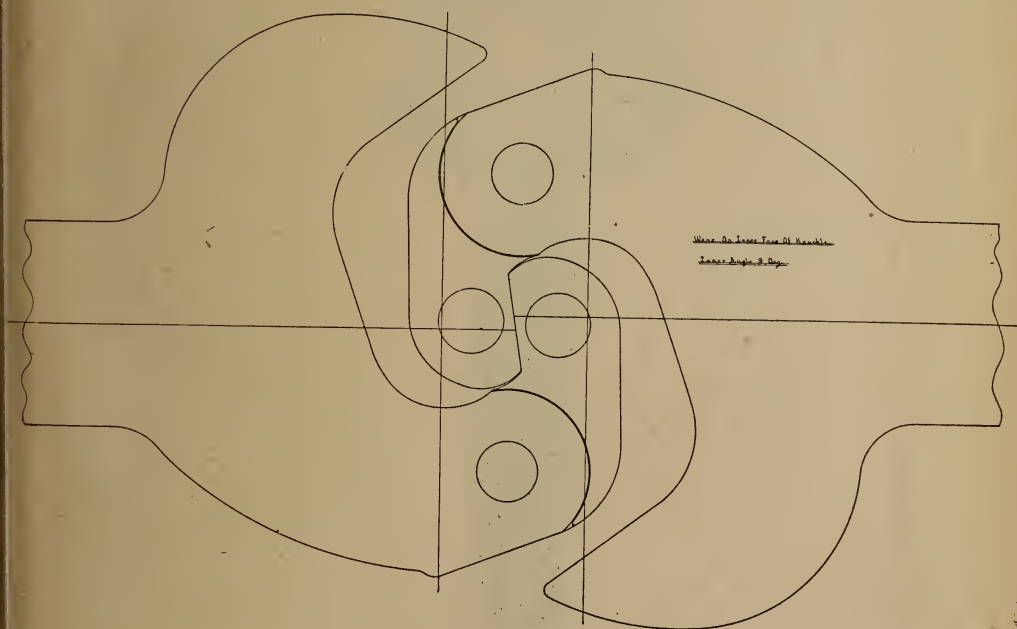


FIG. 7



FIG. 8



FIG. 9

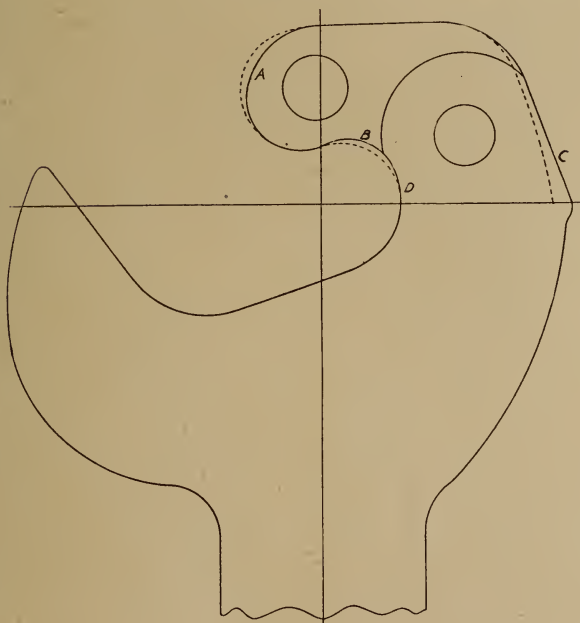


FIG. 10.

Motion was seconded and carried.

MR. TIMMS: Gentlemen, I thank you. We have used the contour, as shown in Fig. 6, ever since we have been in the coupler business, and have found them, from experience, to be better in several ways than what is known as the M. C. B. contour. We do

not want to criticise or ignore the labors of the M. C. B. association in any degree in establishing the M. C. B. lines; on the contrary, we feel they did a great work in bringing them about. On the other hand, we are progressing in improvements and are constantly bringing out new ideas. In establishing the lines we use, we accomplish results which are essential, not only to the strength, but also to the wear of the coupler. The illustrations, Figs. 7, 8 and 9, were taken from couplers which have been in service, and it is readily seen that the inner faces of the knuckles wear in a hooked position, and do not wear in a manner to crowd apart.

I will endeavor to explain more fully the advantages of the improved contour we use, which is also shown in Fig. 10, where we show the M. C. B. lines broken and the improved lines solid. It will be seen that at A we have cut away a portion of the nose of the knuckle; this is done for the purpose of giving clearness between the nose of the knuckle and the throat of the head at D, so that when two couplers are coupled together, the center draft lines overlap each other $\frac{1}{8}$ inch inwardly. This will allow the couplers to pull closer together and not crowd apart as shown in Fig. 6. The cut-away portion of the knuckle at A serves for another important purpose in the construction of the coupler. At the lugs, or ears, at C, you will note that the improved lines extend outward from the M. C. B. lines; this gives more metal at this point, not only to the lugs, or ears, but to the knuckle across the pivot-pin hole, where a great many knuckles break or bend when constructed on the M. C. B. lines. The thickness of metal we get across the pivot-pin at C, by the use of the improved lines, is $1\frac{1}{4}$ inches each side of the pin hole, as against $\frac{1}{2}$ inch by using the M. C. B. lines. We feel that this alone is of vital importance to the coupler. Another point of advantage in preventing the couplers from wearing so as to crowd apart, is that we do away with a portion of the incline, which is marked at B and D, Fig. 10. To fully appreciate the necessity of doing away with, as much as possible, the incline, one only needs to place two tracings of the M. C. B. lines together and he will readily see that the nose of the knuckle fits closely into the throat of the head at D, so that every movement of the couplers tends to crowd them apart and cause the points of the knuckles to wear, as shown in Fig. 6.

As to the M. C. B. gauge, it is readily seen that the points of bearing touch upon the improved contour the same as upon the M.

C. B. contour. I would recommend that the length of the guard arm extend one inch beyond the cross section line, as laid down by the M. C. B. association.

I would also call your attention to Figs. 7, 8 and 9; it will be seen that the wear is on an inner angle of 9 degrees, in a hooked position. This represents the improved M. C. B. lines. Fig. 6 shows that the inner faces of the knuckles wear at an outer angle of $8\frac{1}{2}$ degrees. These are the M. C. B. lines.

MR. DELANO: I want to say, on behalf of the committee, that they are really quite anxious to have an expression of the sense of this Club on the recommendations made, and I hope that some motion will be made to test the opinion of the Club on the subject.

As to the point made by Mr. Timms, I think, and no doubt the committee will agree with me, that it is quite possible that any one starting in with free hand, not fettered in any way by lines previously made, could design something which, in his opinion at any rate, and possibly by actual test, would prove better than these M. C. B. lines. Nevertheless, we do want to call your attention to the fact that the committee stands squarely and emphatically on the point that the M. C. B. lines are entirely satisfactory, that they do not require changing, and that it is too late now, with many roads fully equipped with M. C. B. couplers, and the rolling stock of the country generally equipped to the extent of about 90 per cent., to begin "monkeying with the buzz-saw"—that is the only way I can put it. I think that Mr. Timms may have an improvement over the M. C. B. lines, but I think we will have to stick to the M. C. B. lines, because we have gone too far now to make a change.

MR. RHODES: I would like to endorse Mr. Delano's remarks on the M. C. B. coupler, as to its being a very good coupler. I say this more particularly because there has been an attempt (lately) to underestimate the work that the M. C. B. association has done on the M. C. B. coupler. I think that those who take this line of argument have not gone through the trouble and difficulties that the railroads used to experience before they had the M. C. B. coupler. I have made a great many inquiries recently among our men who actually operate the trains, and I have learned what those who are familiar with the working of the couplers have expected; namely, that it is a most successful coupler. I believe it would not be possible to run our fast freights and fast passenger trains in the success-

ful way we are now doing if we did not have the vertical plane coupler. I think that what this committee says about the importance of following the M. C. B. lines, in place of, at this day, trying to branch out into something different, is a very strong argument.

MR. MORRIS: I move that the report be received, printed in the minutes, and a copy of the Proceedings containing the report be sent by the Secretary to the committee of the M. C. B. association on couplers, together with the statement that the report is endorsed by the Western Railway Club.

The motion was seconded and carried.

MR. MACKENZIE: Does that include Mr. Barr's suggestion for a gauge?

THE PRESIDENT: That is embodied in this report.

MR. MACKENZIE: And also the one submitted by Mr. Fildes?

THE PRESIDENT: Yes.

We are now ready for the report of the committee on M. C. B. rules, which report follows:

CHANGES RECOMMENDED TO BE MADE IN THE RULES OF INTERCHANGE.

March 31, 1899.

TO THE MEMBERS OF THE WESTERN RAILWAY CLUB :

Your Committee appointed to make a report on the revision of the Rules of Interchange, for the April meeting of the Western Railway Club, beg leave to submit the following:

In this report, any rule or section or note which, in the opinion of the Committee, does not require revision, is not mentioned.

Rule 3, Sec. 13. Your Committee would recommend the following: "Flat sliding, if the spot caused by sliding is $2\frac{1}{2}$ inches, or more in length, and if, in such cases, the mate wheel has a flat spot 2 inches, or more in length the delivering company should also be responsible therefor."

Rule 3, Sec. 17. This section does not express clearly the intention under which it was framed. Your Committee would recommend that it read as follows: "Cut journals, axles bent or axles rendered unsafe by unfair usage, derailment or accident." This does not apply to axles less than M. C. B. limit, which are bent.

Rule 3, Sec. 20. Your Committee recommends that this section read as follows: "Defective, missing or worn-out parts of brakes which have failed under fair usage, except missing material on cars offered in interchange."

Rule 3, Sec. 24. Add to the end of this rule, Rule 3, Sec. 28, so that it will read: "Except as provided for in Rule 5, Sec. 4, and Rule 3, Sec. 28."

Rule 3, Sec. 44. (New section): "Any damage to the body of the car from the outside above the sills denotes rough usage."

Rule 4, Sec. 1. Add: "And any car having pin-and-link drawbars on and after January 1, 1899, shall have the same removed and replaced with M. C. B. couplers, and the cost of the same shall be charged to the car owner."

Rule 4, Sec. 5. Your Committee recommends that another paragraph be added to this section, reading as follows: "Metal brake beams of whatever make may be used if fitting properly to the hangers, rods, etc., which are standard to the car, and if they are equipped with M. C. B. heads."

Rule 4, Sec. 14. The sentence reading as follows: "This card shall specify fully the repairs made and reason for the same, date and place where made and name of road making repairs," should be modified so as to read as follows: "This card shall specify fully the repairs made, the reason for same, the name of road making the repairs, date and place where made, whether material used in repairs is new or second-hand, in case the rules provide different prices for new and second-hand material."

Rule 4, Sec. 15. Transpose Rule 5, Sec. 3b, so as to bring it under the head of instructions for repair men, and add: "In addition to the use of the joint

evidence card for statement of wrong repairs, it may also be used for statement of defects which occasion question at interchange points," so that Sec. 15, Rule 4, will read: "The evidence of a joint inspector, or the joint evidence of two persons, one representing the owner of the car, and the other representing the delivering road, that the repairs are not proper, shall be final. In addition to the use of the joint evidence card for statement of wrong repairs, it may also be used for statement of defects which occasion question at interchange points. The joint evidence card used for this purpose shall be of the following form," etc.

Rule 5, Sec. 1. Add the following: "If repair card and stub do not state positively whether new or second-hand material was applied, charge shall be made on the basis of second-hand material when a difference between the price of new and second-hand material is provided in the rules. Also if repair card and stub do not specify whether car is loaded or empty, charge shall be made on the basis of empty car, when a difference in the charge is specified in the rules for empty and loaded cars."

Rule 5, Sec. 3c. Your Committee would call the attention of the Club to a discrepancy between the requirements of this section and Section 3b, and believe that when the joint evidence card covering wrong repairs is accompanied by the repair card on which the joint evidence is made, that the requirements of Section 3c is cumbersome, causes delay, and is unnecessary.

Rule 5, Sec. 5. Omit "bills for wheels and axle work should be in the following form," and substitute the following: "In making bills under these rules, the information necessary for the car department, should be embodied on the following forms, whether the same is made as a bill or as a statement to accompany a bill."

(See samples of blank attached.)

Rule 5, Sec. 10. Add to the list of materials: "Brake shoes, 30c." Change "freight car paint, mixed" to "Mineral freight car paint, mixed, 5c. per lb." "Lead freight car paint, mixed, 15c. per lb."

Add as a note to the list of material the following: "Not more than 1 lb. of mineral paint shall be charged for 15 sq. ft. of surface covered, and not more than 1 lb. of lead paint for 12 sq. ft. of surface covered. No charge to be made for material for lettering."

Rule 5, Sec. 10. Paragraph following list of material on the subject of weight of bearing. Add after the words "13 lbs." the following: "and the weight charged for journal bearings for journals 9 inches long and less than 10 inches long shall not exceed 18 lbs."

Rule 5, Sec. 10. Fourth paragraph on page 28. Amend the last sentence of this paragraph to read as follows: "No bill shall be returned for correction account of error, for less than \$1.00 in aggregate of bill, but said bill shall be passed for payment at once and the alleged error brought to the attention of the road rendering the same within 60 days from date of bill. The receiving road shall at once issue a letter of authority for counter-bill to cover the acknowledged error, said letter to be attached to the bill as authority."

Rule 5, Sec. 10. Amend "Air brake hose, 1¼-inch complete, with fittings, \$2.00," to read: "New air brake hose 1¼-inch complete, with fittings applied, \$2.00." Add: "Second-hand air brake hose, 1¼-inch complete, with fittings applied, \$1 00." Make the same change with reference to 1-inch air brake hose, with the charge for new hose \$1.75 and the charge for second-hand hose \$1.00. In third paragraph on page 28 omit the words "in the case of link-and-pin drawbars and scrap M. C. B. couplers and parts of same."

Rule 5, Sec. 11. Amend "One coupler complete, \$7.50" to read, "one coupler complete, \$6.50"; one coupler shank \$4.50 to read, "one coupler shank \$4.00."

Rule 5, Sec. 17. Add to the list of labor charges the following: "Straightening one bent axle, 80 cents."

Rule 5, Sec. 18. Add to the list of items: "Angle cock, grinding in, 10 cents."

Rule 5, Sec. 23. Add to the list of items for switching roads are allowed to render bill against car owners, the following: "Center pin, drawbar springs and followers."

Rule 7, Sec. 1. Amend the form of Home Card so as to add car number and initials.

Committee	{	J. N. BARR, <i>Chairman.</i>
		THOS. FILDES,
		PETER H. PECK,
		T. B. KIRBY,
		R. D. SMITH.

DISCUSSION.

THE PRESIDENT: If any member present wishes to raise objections to other rules than those recommended by the committee, he is privileged to do so. Too much time would be consumed in reading the rules section by section, so I will instruct the Secretary to call out the sections by number, and if there is no objection we will pass over them.

The Secretary then called out the rules and sections by number until sections were reached for which changes had been recommended by the committee, which sections and recommended changes were then read by Mr. Barr and explanations made.

Rule 3, section 13.

MR. BARR: I will say, Mr. Chairman, in this connection, that I had this matter investigated to learn to what it amounted. For three months of 1899 there were 4,775 repairs of wheels drawn; of this number 327 were slid flat, and out of this number of slid flat wheels, the number of repairs in which one was 2½ inches and over, and the other 2 inches, was 16. So that it is a very small thing anyhow, whether the change be made or not.

On motion, the recommendation of the committee was adopted.
Rule 3, section 17.

On motion, the recommendation of the committee was adopted.
Rule 3, section 20.

MR. H. F. BALL (L. S. & M. S. Ry.): I would like to ask the chairman of the committee if the committee recommends taking out that part of this section which makes the delivering company responsible for defective and worn-out brake material? I understood it was put in for the purpose of having the different roads having air brake material do their proportion of the work.

MR. BARR: I think it is not the intention of the roads to make the delivering company responsible for defective or worn-out parts of brakes, only for missing parts. That is what we recommend, at all events.

On motion, the recommendation was adopted.
Rule 3, section 24.

MR. BARR: That is merely a correction.
Recommendation was adopted.

MR. BARR: The committee would add a new section, 44, and recommends that there be an addition to the definitions of rough usage, as follows: "Any damage to the body of the car from the outside above the sills denotes rough usage." And the railroad having the car in possession is responsible.

MR. HASKELL: I would like to ask Mr. Barr if the damage referred to is above the top side of the sill, or above the bottom side?

MR. BARR: You may take it as you please; I should say it means the bottom side of the sill.

MR. BALL: Does it include the running boards blown off?

MR. RHODES: I would like to suggest an amendment to the committee's recommendation. I do not know whether it is quite the same. It seems to me there is a chance that on some cars the sills may be damaged and cracked on the upper side and out of sight, and whether the other clause that we have about visible defects would quite cover it or not I do not quite know. The sills of some of our refrigerator cars are pretty well covered up, so that it is impossible to see the defects in the sills, and cases will arise where a railroad company may deliver a refrigerator car to a car owner, and when the owner overhauls the car and discovers the sills cracked, he will bring a bill against the railroad company that delivers the

car home, and hold the road responsible. I think that it is not altogether fair on the railroad company which handles the car, because it cannot possibly tear the car apart to see whether the sills are cracked or broken. I think that the section might read a little better; for instance: "Any visible damage to the body of the car from the outside above the sills denotes rough usage."

MR. BARR: It seems to me that Mr. Rhodes would cover, then, the item of running boards blown off. It is not the intention to cover that, but this is one of a number of disputes about damaged doors, damaged corner of cars, damaged end posts, etc., and all these cases of damage mean, as far as I can see, that the car comes in contact with something else to cause the damage. If the car should come in contact with something else and be damaged, then any such damage on the outside of the car above the sills is considered unfair usage. That is simply the object, and it seems to me that in view of all these other rules where we have combinations of broken drawbars, couplers, and so on, that the word "damaged," almost explains itself here. If the body of the car is damaged by coming in contact with something, whether it is the load of another car or whatever it may be, if it is damaged above the sills in that way, the damage could be repaired at the expense of the road causing such damage. That is all.

MR. MACKENZIE: I want to know if Mr. Barr will concede that section 24 governs defects to the sills of a refrigerator car that has a floor below the sills? It speaks of the defects above the sills; now the sheathing may be broken on the side of the sill, and it is more frequently done there than at any other part of the car.

MR. R. D. SMITH (C., B. & Q. R. R.): The suggestion to make this new section was brought about by a letter to the committee asking to have such a rule embodied. It looking it up since our committee meeting, however, I do not quite see the need of it. It seems to me that section 27 of Rule 3 covers the case equally as well as the new section. I am opposed to adding to the rules anything that will make them more difficult of understanding, and I do not see that anything will be gained by having the new section.

MR. STARK: It may be possible that the wording of that recommendation might be changed somewhat, but there is a divergence of opinion between inspectors as to the responsibility for repairs to a car when the end is broken, or the door stops scraped off, and it

very frequently happens that the car is punched in by loading from another car, and the question arises, is the owner responsible? I think this should be very clearly defined in the rules.

THE PRESIDENT: There is no rule to this effect. It is a recommendation of the committee that a section 44, as read by Mr. Barr, be added. In the absence of a motion to add this rule, there is no question before the house.

It was moved and seconded that the recommendation of the committee be adopted.

MR. F. W. BRAZIER (Ill. Cent. R. R. Co.): I do not understand that section. For instance, would not that cause a great deal of trouble for the inspectors? I think our rules cover it, and I would feel, like Mr. Smith, that it was unnecessary. I do not want to put anything in that will make more work for the inspectors, but I believe, like Mr. Barr, that for all such damages as the roads are doing they should pay. I think we are charging too much for fair usage that is caused by unfair usage, and I think we ought not to encumber our rules with anything more.

MR. BALL: I would like to make an amendment to the motion—that the recommendation read: “Any damage to the sheathing, roof or doors of a car, by being struck from the outside, be denoted as rough usage.”

Seconded by Mr. Mackenzie.

MR. BARR: I have this to say. This matter is so extremely unimportant that the idea of the Club taking up five minutes one way or the other is a little absurd to me. Now, it does not make a bit of difference whether the recommendation goes in or does not go in. It will possibly settle a few disputes that come up, and that is all. It is generally recognized that in case of damage to the outside of the car, the person having the car in his possession is responsible for it, but it does not make any practical difference whether or not the recommendation goes in.

THE PRESIDENT: The question is now on the amendment.

The amendment was put to vote and lost.

The question then recurring on the adoption of the recommendation of the committee, the same was put to vote and lost.

Rule 4, section 1.

It was moved and seconded that the recommendation of the committee be adopted.

MR. BRAZIER: It is going to lead those who have not the couplers to an endless lot of correspondence in some cases, and I would like to suggest the following amendment:

Cars not equipped with M. C. B. couplers to comply with Interstate Commerce Law, may, after Jan. 1, 1900, have couplers applied by party having such cars in their possession, rendering bill against owners for cost of changing at following figures: Couplers complete, \$6.50 each; lift rods and castings complete for one end of car, 60c. each; labor for applying couplers and lift rods, three hours each end of car; credit to be given for old bars removed at actual weights, scrap figures. Old pocket rear-end attachments may be used when same are in good condition and right size. Couplers that require new pocket tail-straps, 1 x 4-inch iron must be used. If necessary to change draft timbers on account of the draft rigging not being in proper position, owners must be notified, who will authorize the change. Deadwoods may be reduced to not less than 4½ inches to clear horn of coupler 1¾ inches.

You may think that is foolish, but we have been criticised because we did not leave an 1¾-inch space when we left only ⅞-inch less. If you do business with such particular people, you will see the necessity for this recommendation. There are a great many couplers and drawbars that are not standard length, and we have a way of correcting this on cars with the continuous draft rigging, by putting in a longer spring, lengthening the rods and reducing the deadwood when the drawbar is too long, but we never reduced the deadwood to less than 4½ inches.

The foregoing amendment was put to vote and lost.

THE PRESIDENT: The original recommendation of the committee is now before the Club; the motion has been made and seconded. If you will permit the Chair, I will say a word on this subject: I want to say that I think we are getting into very deep water in making recommendations of this kind. If we embody in our Rules of Interchange a clause authorizing inspectors to refuse a car after January 1, 1900, that is not equipped with the automatic couplers it would be the correct thing to do. The heads of departments should co-operate with the operating department to get all cars with the link-and-pin drawbar off the foreign lines and into the possession of the owners by the time the law goes into effect.

MR. MACKENZIE: I offer as an amendment the following: "A road having in its possession at any time between September 1, 1899, and January 1, 1900, a car equipped with link-and-pin draw-bar, broken while in service, may replace this with an M. C. B.

coupler." The foregoing being in addition to the recommendation. The foregoing amendment was put to vote and carried.

THE PRESIDENT: The motion is now on the recommendation of the committee as amended. All in favor of the motion as amended will give their assent by saying aye. (Carried.)

Rule 3, section 5.

On motion, the recommendation of the committee was adopted.

Rule 4, section 14.

Recommendation of committee was adopted.

Rule 4, section 15.

MR. R. D. SMITH: It seems to me that if this section is passed as recommended, it will make more or less disputes over bills, especially if section 3c to Rule 5, a little further on, that is recommended by the committee, is adopted. As this matter stands now, we have to settle our disputes before a bill is made, and if it is passed as recommended, I am afraid that bills will be made on the repair cards and disputes over the bills being proper will arise. As it is at present, all disputes are settled before the bills are rendered, and it seems to us it is a good bit better to let the section alone.

THE PRESIDENT (to Mr. Barr who had just re-entered the room): Mr. Barr, the motion is on the adoption of your recommendation as to adding section 15 to Rule 4. The objection to the recommendation is to the effect that, as the rule stands to-day, disputes are settled before bills are rendered. Under the rules as per recommendations of committee, the bills are to be rendered and then the disputes are to be settled.

MR. PECK: I do not understand it that way. These repair cards shall be final. It does not say that you will make a bill on this joint evidence card, but that it shall be evidence, as far as the inspectors are concerned, that the repairs are wrong.

THE PRESIDENT: What will you do with the joint evidence card unless you render a bill on it?

MR. PECK: What do you do with it now?

THE PRESIDENT: Render a bill on it.

MR. BARR: I think there is some omission here. After you get this card you must write to the party making the repairs and ask him to give you authority for making the bill. I do not know how much correspondence it involves, but there is Mr. Grieb; he knows.

MR. J. C. GRIEB (C. M. & St. P. Ry.): We have at least forty cases of this kind each month, and some people are not satisfied with only one request, they insist on our sending them two or three, and it seems to me there is no occasion for any argument when we have the joint evidence card. The joint evidence is final; there is no occasion for any question.

MR. MACKENZIE: I think we might go further, and if there is any other way to make this more binding, I would like to have it. I want to see that joint evidence card made final. That is what this rule proposes to do.

It was suggested that just previous to the words "shall be final" there be inserted the words "when accompanied by a repair card."

MR. BARR: We use the joint evidence card only for wrong repairs. There are a great many cases in which there are defects, and my idea is this; that by having the two inspectors at that point sign a joint evidence card as to the actual condition of a car, the car might then go forward without any delay. Utilize the joint evidence card for that purpose. I think we have all found that the joint evidence card, if carried out, is a good thing, and the object of the clause is to extend it to defects as well as to wrong repairs. That is the point in that particular place.

Recommendation of the committee was adopted.

Rule 5, section 1.

Recommendation of committee was adopted.

Rule 5, section 3c.

MR. BARR: The proposed rule is not put in here, but we recommend that section 3c be modified so that in the case of wrong repairs covered by a repair card, that the joint evidence card and the repair card accompanying it shall be authority for a bill. We recommend that that be inserted in some way. It fully covers it, although we have not written up the rule.

I would recommend that after section 3c as it reads, there shall be added the following: "The joint evidence card, accompanied by a proper repair card, shall be used as authority for rendering bills for cost of improper repairs."

On motion, the recommendations of the committee were adopted.

Rule 5, section 5.

On motion, the recommendations of the committee were adopted.

Rule 5, section 10.

Recommendation of committee was adopted.

Rule 5, section 10, Mr. Barr read recommendation on "Air-brake Hose."

THE PRESIDENT: I wish to call your attention to the fact that if a rule like this is adopted, it will permit any road to put second-hand air-brake hose on our cars and charge us for the same.

MR. BARR: Don't they do it now?

THE PRESIDENT: No, sir. I think we are going to make a mistake in that.

MR. BARR: Put an old one on, and charge new prices.

THE PRESIDENT: This does not say "pieced hose;" it says "second-hand hose."

MR. BARR: There is nothing in the rules now to prevent anyone from putting second-hand air-brake hose on your cars. This would be a matter where they would have to be dishonest in order to do it.

Recommendation of committee was adopted.

Third paragraph, page 28 was read.

MR. BARR: Now there do not seem to be any good reasons why M. C. B. couplers and parts of same should be an exception to the general rule, that whenever scrap credits are allowed the weight of scrap credited shall be equal to the weight of new metal applied.

Adopted.

Rule 5, section 11.

MR. DELANO: Will the Chairman say why that price was reduced?

MR. BARR: The reduction in price was made because we are not, as a rule, paying as much as the price given. Prices are going up, and it could not have as much force as it had, but the recommendation was made in view of the prices that have been prevailing.

MR. MACKENZIE: I think that under the action we have been taking to-day, we ought to be very careful about reducing those prices. We are coming to use a better coupler and probably will have to pay more for it.

Motion to adopt recommendations of the committee was put to vote and lost.

Rule 5, section 17.

MR. MACKENZIE: I would like to have the committee explain why they put that in.

MR. BARR: Mr. Peck will answer that.

MR. PECK: One charge made was \$1.80. I did not want to stand the price, that is all.

MR. BARR: There are all sorts of charges made, from 60 cents to \$2.00.

MR. MACKENZIE: Where is the rule governing this thing? Against whom are you going to make a charge? You can charge nobody for a bent axle.

THE PRESIDENT: Yes, you can, under defect card.

MR. MACKENZIE: Yes, that is true, but that is very seldom done.

THE PRESIDENT: If it is done on a defect card, we ought to charge them \$2.00.

Recommendation of committee was adopted.

Section 18.

Recommendation of committee was adopted.

Section 23.

Recommendation of committee was adopted.

Rule 7, section 1.

MR. BARR: Now, Mr. Chairman and gentlemen of this Club, in order to show the penetration of your committee, and the labor that they have expended on these rules, I want to call your attention to what we recommend in this case. We have a card that has been in existence, I think, for twenty years, a "home card." The necessity of the correction has been passed by all the conventions, all the club meetings, and in fact every meeting on the subject that has occurred for the last twenty years. We find that there is no car number or initials to show to what the card refers, and we recommend that the car number and initials be put in.

Recommendation of committee was adopted.

Mr. Mackenzie asked permission to turn back to Rule 5, section 4, for the purpose of amending the same. This was granted.

MR. MACKENZIE: I would suggest that section 4, Rule 5, read as follows: "Bills may be rendered against car owners for the labor only of replacing couplers, drawbars, drawbar springs, followers, yokes, spindles, brake-beams (including their attachments, such as

shoes, heads, jaws and hangers) brake levers, top and bottom brake rods that have been lost on the line of the company making the repairs."

Carried.

Adjourned.

RULES AS RECOMMENDED CHANGED.

The following are the sections in which changes were recommended by the committee, the changes being approved by the Club. The additions are in italics:

Rule 3, Sec. 13. Flat sliding, if the spot caused by sliding is $2\frac{1}{2}$ inches, or more in length, *and if, in such cases, the mate wheel has a flat spot 2 inches, or more in length,* the delivering company should also be responsible therefor. (Care should be taken to distinguish this defect from worn through chill.)

Rule 3, Sec. 17. Cut journals, axles bent or *axles* rendered unsafe by unfair usage, derailment or accident. *This does not apply to axles less than M. C. B. limit, which are bent.*

Rule 3, Sec. 20. Defective, missing or worn-out parts of brakes which have failed under fair usage, except *missing material* on cars offered in interchange.

Rule 3, Sec. 24. Locks, grain doors and all inside or concealed parts of cars missing, or damaged under fair usage, and failure or loss under fair usage of any part of the body of the car, except as provided for in Rule 5, Section 4, *and Rule 3, Section 28.*

Rule 4, Sec. 1. Any car having defects which render it unsafe to run, unsafe to trainmen, or to any lading suitable to the car, may be repaired. *And any car having link-and-pin drawbars on and after January 1, 1899, shall have the same removed and replaced with M. C. B. coupler, and the cost of the same shall be charged to the car owner. And a road having in its possession at any time between September 1, 1899, and January 1, 1900, a car equipped with link-and-pin drawbar broken while in service, may replace this with an M. C. B. coupler.*

Rule 4, Sec. 5. When M. C. B. couplers of another make are placed upon a car, the uncoupling arrangements shall be made operative at the expense of the company making the repairs.

When M. C. B. couplers, knuckles, metal brake beams, wheels or axles are replaced under conditions which make them chargeable to the owner, it must be plainly stated on the repair card and stub whether the metal is new or second-hand.

Metal brake beams of whatever make may be used if fitting properly to the hangers, rods, etc., which are standard to the car, and if they are equipped with M. C. B. heads.

Rule 4, Sec. 14. When repairs of any kind are made to foreign cars, a repair card shall be securely attached to outside face of intermediate sill between cross-tie timbers. This card shall specify fully the repairs made, the reason for same, the name of road making the repairs, date and place where made, *whether material used in repairs is new or second-hand, in case the rules provide different prices for new and second-hand material.* The card shall be provided with a stub, which will duplicate the information on the card, and stubs must be forwarded with the bill.

If no bill is to be rendered, the repair card stub must be forwarded on or before the twentieth day of each month, with the words "no bill" written across the face of the repair card stub. In case it is not the intention to render bill, the words "no bill" shall be written across the face of the repair card.

The repair card shall be $3\frac{1}{2}$ by 8 inches, and the stub $3\frac{1}{2}$ by 4 inches. The card shall be printed on both sides in black ink, and shall be filled in on both sides with ink or black indelible pencil.

Rule 4, Sec. 15. (This is at present Rule 5, Sec. 3b, with the addition shown by italics.) The evidence of a joint inspector, or the joint evidence of two persons, one representing the owner of the car, and the other representing the delivering road, that the repairs are not proper, shall be final. *In addition to the use of the joint evidence card for statement of wrong repairs, it may also be used for statement of defects which occasion question at interchange points.* The joint evidence card used for this purpose shall be of the following form. (The form of card not changed.)

Rule 5, Sec. 1. Bills may be rendered for work done under Section 1 of Rule 4, except in cases where owners are not responsible and the car bears no defect card covering the defects repaired, stating upon the bill the date and place where the repairs were made; the repair card stub or defect card to accompany the bill. *If repair card and stub do not state positively whether new or second-hand material was applied, charge shall be made on the basis of second-hand material when a difference between the price of new and second-hand material is provided in the rules. Also, if repair card and stub do not specify whether car is loaded or empty, charge shall be made on the basis of empty car, when a difference in the charge is specified in the rules for empty and loaded cars.*

Rule 5, Sec. 3c. The joint evidence card shall not be used as authority for rendering a bill, but shall be sent to the company against which evidence is presented, and it shall furnish defect card covering the wrong repairs if it made them. *The joint evidence card, accompanied by a proper repair card, shall be used as authority for rendering bills for cost of improper repairs.*

Rule 5, Sec. 4. Bills may be rendered against car owners for the labor only of replacing couplers, drawbars, *drawbar springs, followers, yokes, spindles*, brake beams (including their attachments, such as shoes, heads, jaws and hangers), brake levers, top and bottom brake rods that have been lost on the line of the company making the repairs.

Rule 5, Sec. 5. (Present section omitted and substitute following.) *In making bills under these rules, the information necessary for the card partment should be embodied on the following forms, whether the same is made as a bill or a statement to accompany a bill. (No form shown).*

Rule 5, Sec. 10. Add to the list of materials: "Brake shoes, 30c." Change "freight car paint, mixed" to "mineral freight car paint, mixed, 5c. per lb." "Lead freight car paint, mixed, 15c. per lb."

Add as a note to the list of material the following: *Not more than 1 lb. of mineral paint shall be charged for 15 sq. ft. of surface covered, and not more than 1 lb. of lead paint for 12 sq. ft. of surface covered. No charge to be made for material for lettering.*

Rule 5, paragraph under list of material. The weight charged for new journal bearings for 7-inch journals and over, but not 8 inches long, shall not exceed 10 lbs., and the weight charged for new journal bearings for journals 8 inches long and less than 9 inches long shall not exceed 13 lbs. *And the weight charged for journal bearings for journals 9 inches long and less than 10 inches long shall not exceed 18 lbs.* The weight of scrap credited must be one-half the weight of the bearing charged.

Rule 5, third paragraph, page 28. Whenever scrap credits are allowable the weights of scrap credited shall be equal to the weights of the new metal applied, except as otherwise provided in the rules, and except (omit: in the case of link-and-pin drawbars, and scrap M. C. B. couplers, and parts of same, and) material applied on defect cards, in which cases the weight and kind of metal removed shall be credited.

Rule 5, fourth paragraph, page 28. Bills shall not be rendered for amounts less than 25 cents in aggregate, but charges for items less than 25 cents may be held until they amount to that sum, provided said aggregate is rendered within sixty days. No bill shall be returned for correction on account of error for less than (the following to be omitted: "25 cents, but request shall be made for credits and adjustment in subsequent month.") *100 cents in aggregate of bill, but said bill shall be passed for payment at once and the alleged error brought to the attention of the road rendering the same within sixty days from date of bill. The receiving road shall at once issue a letter of authority for counter-bill to cover the acknowledged error, said letter to be attached to the bill as authority.*

Rule 5, Sec. 10. List of material. Amend "Air-brake hose, 1¼-inch complete, with fittings, \$2.00," to read: "New air-brake hose 1¼-inch complete, with fittings applied, \$2.00. Add: "Second-hand air-brake hose, 1¼-inch complete, with fittings applied, \$1.00." *Make the same change with reference to 1-inch air-brake hose, with the charge for new hose \$1.75 and the charge for second-hand hose \$1.00.*

Rule 5, Sec. 17. Add to the list of labor charges the following: *Straightening one bent axle, 80 cents.*

Rule 5, Sec. 18. Add to the list of items: *Angle cock, grinding in, 10 cents.*

Rule 5, Sec. 23. Add to the list of items for which switching roads are allowed to render bill against car owners, the following: "*Center pin, drawbar springs and followers.*"

Rule 7, Sec. 1. Amend the form of Home Card so as to add car number and initials.

THE DAVID L. BARNES LIBRARY.

SPECIAL NOTICE! The David L. Barnes Library of this Club, at 1750 The Monadnock, Chicago, is open for the use of members and their friends, and we hope it will be used freely. It is open on week days from 9 a. m. to 5:30 p. m., except on Saturday, until 3 p. m. Books must not be removed from the Library, but the librarian will assist visitors in finding information and will promptly reply to letters from out-of-town members desiring information from the Library. Donations of books and technical publications will be gratefully received.

TRUSTEES OF THE LIBRARY.

List of duplicate copies of the Proceedings of the Western Railway Club which are in the David L. Barnes Library and are for sale or exchange:

1888—Sept. and Oct. (bound in one).

1889—Oct., Dec.

1890—Feb., Sept., Oct., Nov., Dec.

1891—Jan., Mar., Apr., May, Oct., Nov.

1892—Jan., Feb., Apr., May, Sept., Nov., Dec.

1893—Two complete volumes; also single copies of Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

1894—Jan., Mar., Apr., May, Oct., and Index of subjects discussed by the Club.

1895—Jan., Apr., Sept., Oct., Nov., Dec.

1896—One complete volume, also single copies of Jan., Mar., May, Sept., Nov., Dec.

1897—Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec., also two complete volumes.

1898—Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

Correspondence relating to the Library, donations of books, periodicals, etc., for the files, or duplicates sent for exchange should be addressed to H. de K. Woods, Librarian, 1750 Monadnock, Chicago.

OFFICIAL PROCEEDINGS
OF THE
WESTERN RAILWAY CLUB.

ORGANIZED, April, 1884.

INCORPORATED, March, 1897

MAY 25, 1899.

Published monthly, except June, July and August, by the Western Railway Club,
225 Dearborn Street.

VOL. 11—No. 9.

CHICAGO, ILL.

{ \$2.00 PER YEAR,
25c. A COPY.

CLUB MEETS THIRD TUESDAY IN EACH MONTH, EXCEPT JUNE, JULY AND AUGUST.

OFFICERS, 1898-1899.

President, C. A. SCHROYER,
Supt. Car Department, C. & N.-W. Ry.

First Vice-President:

F. W. BRAZIER,
Asst. Supt. Machinery, Ill. Cent. R. R.

Second Vice-President:

PROF. WM. F. M. GOSS,
Professor of Experimental Engineering,
Purdue University.

Treasurer:

Directors:

H. G. HETZLER,
Supt. Fght. Terminals, C. B. & Q. R. R.
PETER H. PECK,
Master Mechanic, C. & W. I. R. R.
F. W. SARGENT,
Sargent Company, Chicago.

Board of Directors:

C. A. SCHROYER. JOHN W. CLOUD.
F. W. BRAZIER. H. G. HETZLER.
PETER H. PECK. F. W. SARGENT
PROF. WM. F. M. GOSS.

Secretary:

F. M. WHYTE.
225 Dearborn Street,
Chicago, Ill.

Trustees of the Library:

F. W. SARGENT, Chairman,
WILLIAM FORSYTH,
Aurora, Ill.
A. M. WAITT,
New York City.

The regular monthly meeting of the Western Railway Club was called to order at 2 p. m., Tuesday, May 16, 1899, in the Auditorium Hotel, Chicago. President C. A. Schroyer in the Chair.

Following are the names of those who registered:

Ackerlind, G. A.	Furry, F. W.	Mills, G. F.
Anderson, Geo. T.	Goehrs, Wm. H.	Noble, L. C.
Bischoff, G. A.	Gowing, J. P.	Peck, Peter H.
Brazier, F. W.	Haskell, B.	Rennolds, W. C.
Bryant, G. H.	Hill, Jas. W.	Riddell, Chas.
Bryant, W. E.	Jacoby, W. L.	Sanborn, J. G.
Clark, F. H.	James, Geo.	Scales, R. P.
Clifford, C. J.	Jennings, D. F.	Schroyer, C. A.
Connors, Jas.	Johan, Jacob.	Shea, R. T.
Crane, Chas. A.	Keegan, J. E.	Shields, H. S.
Crossman, W. D.	Keeler, Sanford.	Smith, R. D.
Cushing, G. W.	Kirby, T. B.	Stocks, W. H.
Davies, W. O.	Kirby, W. S.	Whyte, F. M.
Delano, F. A.	Manchester, A. E.	Woods, J. L.
Forsyth, Wm.	Medway, John.	Younglove, T. G.
Fuller, Al.	Mileham, C. M.	

THE PRESIDENT: The first order of business is approving of the minutes of the April meeting; Mr. Timms requests that these corrections be made in his remarks: In the text, page 359, read Fig 10, for Fig. 6. Page 360, 12th line from bottom of page, put in $\frac{1}{16}$, in blank space. If there are no other corrections the minutes will be approved in other respects; hearing no objections they are so approved.

The Secretary will now read the names of the applicants for membership, whose applications were approved by the Directors at their meeting this morning.

The Secretary then read the following names:

- Mr. F. E. Allen, Trav. Engr., C. & N.-W. Ry., Boone, Iowa.
- Mr. A. B. Frenier, Sec.-Treas., Dav. Fd'ry. & Mach. Co., Davenport, Iowa.
- Mr. Geo. Havill, C. M. & St. P. Ry., Perry, Iowa.
- Mr. A. C. Heidelberg, Asst. Supt., C. C. Ry. Co., Chicago.
- Mr. E. J. Jackson, C. B. & Q. R. R., Burlington, Iowa.
- Mr. F. Mertsheimer, Genl. Supt., K. C., P. & G. R. R., Kansas City, Mo.
- Mr. J. Niblock, Supt., Can. Pac. Ry., Medicine Hat, Man.
- Mr. Chas. Pfeiffer, R. H. Foreman, Perry, Iowa.
- Mr. F. G. Stevens, Track Master, C. C. Ry. Co., Chicago.
- Mr. John Throll, Foreman Car Reps., Belt R. R., Chicago.
- Mr. Benj. Vogel, Mech. Engr., D. & H. C. C., Green Island, N. Y.
- Mr. A. N. Willsie, Trav. Fireman, C. B. & Q. R. R., Galesburg, Ill.

THE PRESIDENT: This being the last meeting of the Club year, the annual reports of the officers are in order, and we will hear the reports of the Secretary and Treasurer.

The Secretary then read his report, as printed in the Appendix A to this number.

Moved by Mr. Peck that the report be received and printed in the minutes of the meeting. (Carried.)

THE PRESIDENT: I wish to say that this report was read to the Directors at their meeting this forenoon, and by them approved.

We have a report from Mr. Sargent of the Library Committee that we will be glad to listen to.

Mr. Sargent then read the report as printed in the Appendix B to this number.

THE PRESIDENT: Gentlemen, you have heard the report of the chairman of the Library Trustees. You are probably all aware that previous to the present year the library was maintained by subscription. At the beginning of this year the Board of Directors set aside the sum of \$400 to be used for maintaining the library for this present year. Of that amount about \$339 have been expended, and the investment I consider has been a very excellent one. It will probably require the balance of the \$400 to run the library during the summer months, but in the fall the new Board of Directors will have to provide for the library, and I think that with our financial progress as favorable as it has been in the past year, the Club will be able to take care of the library, and do it very creditably. You will notice that the cash balance on hand at the end of this year is about \$1,800 more than it was a year ago. We will be glad to hear your wishes concerning the disposition of the report that was made by Mr. Sargent.

MR. A. F. DELANO: I was about to move that the report be accepted and spread on our minutes. At the same time I think that we ought not to overlook the fact that the *Railroad Gazette*, with which Mr. Barnes was for a number years connected, contributed for at least two years the entire amount of office rent, and during the current year nearly one-half the rent. We ought not to overlook the fact that we are indebted to the *Railroad Gazette* for their continued contributions for the housing of this library. I move that the report be accepted as presented. (Seconded.)

THE PRESIDENT: Mr. Delano moves, and it is properly

seconded, that the report of the Chairman of the Library Trustees be accepted and properly spread on the minutes. (Carried.)

MR. P. H. PECK: I move that a vote of thanks of this Club be extended to the *Railroad Gazette* for their kindness in contributing to the proper housing of the David L. Barnes Library of the Club. (Seconded. Carried.)

THE PRESIDENT: We will now listen to the reading of the paper prepared by Mr. C. H. Quereau, and entitled "Notes on Hot Main Pins." In the absence of Mr. Quereau the Secretary will read the paper.

The Secretary then read the following paper:

NOTES ON HOT MAIN PINS.

BY MR. C. H. QUEREAU.

With a hope of provoking an interesting discussion I have prepared the following notes on a subject which, no doubt, at one time and another, has caused many a master mechanic much thought and worry.

High-speed passenger engines, more frequently than freight engines, cause annoying delays because of hot main pins. I have in mind a number of this class of engine, having cylinders 20 x 26 inches, steam pressure 200 pounds, and main pins 6 x 6 inches, hauling heavy through trains, which for a considerable length of time gave trouble because their main pins insisted on running hot. The best of phosphor bronze bearings and lubricating oil were used, the greatest pains taken in boring and fitting the bearings, which had ample surface, yet the trouble was not overcome. There was no difference between the bearings which had babbitt strips and those which did not.

It would naturally be assumed that the occasion for hot pins would be greatest when the greatest strain was put on the bearings in handling a heavy train up hill, but a few weeks' study of the subject showed that there were practically no cases of hot pins under these circumstances, but, instead, they occurred while the train was drifting down hill.

An investigation in the roundhouse showed that it was the custom there to ease off the brass at the back end of the main rod, both at the top and bottom, as shown in Fig. 1, the reason given being that, when the pin ran hot the brass would expand and pinch the pin where the halves of the bearings met, unless the fit was eased away at these points. With the fit shown in Fig. 1, which I believe is not uncommon practice, it seems reasonable to assume that, when the engine is drifting, the weight of the back end of the main rod is in this case 422 pounds, carried on the two points marked A, producing a heavy pressure per square inch, which is liable to occasion a hot bearing. This will become more apparent when it is explained that with the main pin fits under discussion the brass is bored a scant thirty-second of an inch larger than the pin, this having been found by experience to be desirable. This line of reasoning naturally leads to the conclusion that the brass should not be eased off at the top, but should be given the same bearing as at the sides, producing the fit shown in Fig. 2. When this was done the trouble from hot main pins ceased, with an exception to be noted later. To overcome the tendency of the brasses to pinch the pin when it becomes hot, the brasses are keyed very solidly, and the edges at the top, where the brasses meet, given a fillet with about one-half inch radius.

It is possible that the fit shown in Fig. 1 will answer on level roads, where there is comparatively little drifting, or on light engines, but on lines where

there are any considerable distances that steam is not used and the engines are heavy, the fit shown in Fig. 2 gives decidedly better results. I am so convinced of the advantages of the fit given in Fig. 2, that our engineers understand that,

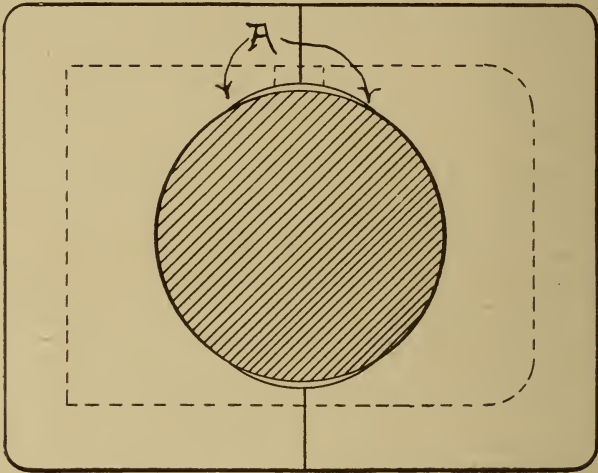


Fig. 1.

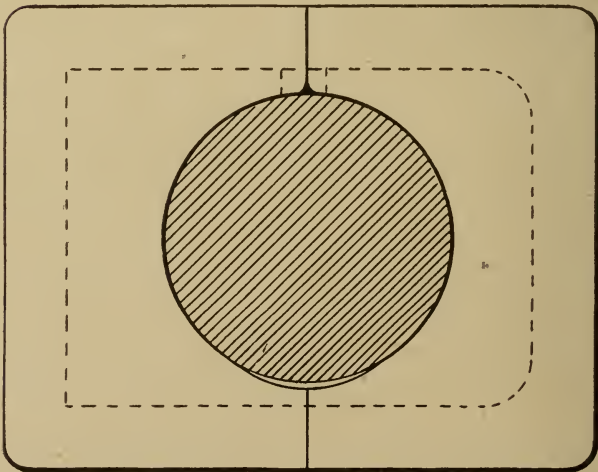


Fig. 2.

when once a new fit is broken in they are held responsible for hot pins, on the ground that it can run hot only because of negligence on their part.

In confirmation of the above line of reasoning, it was found on examining the main pin fit of an engine which had given no trouble for some time by running hot, and had not been given the new fit, that the brass had worn itself to the fit of Fig. 2.

About the middle of September we received six new engines of the same class as those which had caused so much annoyance with hot main pins, which were given the main pin fit shown in Fig. 2. Because of a very heavy freight business it was decided to use the new engines in this service, and for the same reason it was decided best to use them in the freight pool. So great was the need of power that the new engines were run in the pool after having been run only 1,200 miles by assigned engineers to break them in. There was practically no trouble from hot main pins on the new engines till about the middle of November, when there were three aggravated cases in one night, which was the first cold snap of the season. The conjunction of three serious cases of hot pins, after nearly a month of freedom from such trouble, with a cold night, led to the issuing of a bulletin forbidding the use of valve oil in any of the rod cups, and vigorous following up of the bulletin to know that it was obeyed. Since the adoption of the fit Fig. 2 and the prohibition of the use of valve oil on the main pins there has been no trouble because of hot pins.

About nine months ago there were a number of cases when main pins got hot and an investigation showed that a piece of babbitt had stopped the oil hole up, preventing the oil from reaching the pin. In such cases the babbitt was removed from the brass, being replaced in some cases with strips of magnesia or asbestos, and in others with nothing. For the past six months the main rod brasses have been made solid, that is, without recesses for babbitt, and have given the best of satisfaction. The solid brasses have the added advantage that they are cheaper to fit up and are not liable to retain sand from the mold in the recesses.

MR. C. B. CONGER (*Locomotive Engineering*.): This question of hot main pins is a live one among locomotive engineers and traveling engineers. Some brasses and some pins will run hot in spite of any attention which engineers can give them, and when engineers do everything they can for hot pins and are unable to prevent the heating they are inclined to think that something is wrong, either with the brass or with the fit of the brass on the pin. It has been my experience that in a good many cases the brasses have been taken down by the machinists and after fitting up as they consider proper, there is so little bearing surface left that it is impossible that the pins run cool with any strain on them at all. As far as the fit of the pins is concerned, Mr. Quereau has touched upon that, but there are other things about a locomotive that would cause a brass to run hot;

for instance, excessive lead is about as fruitful a source of hot main pins as poor fitting and poor material. You will notice that when an engine is being worked pretty hard to make up time, with the throttle wide open and full boiler pressure, it has a greater tendency to run hot than when under less pressure. It may be that the lead, resulting in such a high strain on the pins on account of the high pressure of steam at one time, causes the pins to become hot, or it may be the excessive compression;—I think that it may be, sometimes, the compression. Give an engine excessive lead and frequently heating of the bearings will result, sometimes it will be the driving boxes, and sometimes the main pin. I have noticed the same conditions that Mr. Quereau has explained, about the easing off of brasses at the back end of the main rod. Generally, on removing the hot brass you will find there is very little surface in contact, the brass afterwards wears down on the pin until it seems to touch the pin at all points and the heating ceases. This being the case, why ought the brasses be cut out at the top and bottom if it is necessary for the little bearing surface left to be increased by wearing, in order that the heating may cease? I think that after the brass is worn down to a bearing and runs cool, it is enough to do to just take off the edges so that it will close up and fit the pin; but you will notice that a good many men take out the metal at the top and bottom bearing surface. One thing that prevents brasses heating is the fact that there is room enough between the pin and half the brass, while the other half is taking the strain, to allow the oil to work down between the loose half and the pin.

MR. F. A. DELANO (C., B. & Q. R. R.): Perhaps the remarks that I am about to make will provoke remarks from others that will throw light on this subject. Mr. Quereau's paper is a very interesting one, though short, and yet I do not quite understand the diagnosis of the case that he gives. I am inclined to think that the explanation of the trouble is different from that he has given; in other words, that the method he has mentioned of fitting up the brasses has been defective in practice and not in theory. I once read of a Frenchman who was told a rather big story by a Yankee. The Frenchman did not want to be so impolite as to say that he doubted the Yankee's word, so he said: "Doubtless you are correct, but God knows it is impossible." I feel like saying the same to Mr. Quereau.

We can get some pointers in locomotive practice from the experience in marine practice. As I understand it, in marine practice, in fitting up brasses for main crank pins they bore out brasses with heavy liners between the two halves, then when they put these brasses on the pin without the liners and tighten or key them right down onto the pin, the result is that they get a slightly elongated opening on a circular pin, which has the effect of relieving the bearing on the top and bottom just as Mr. Quereau has shown in his sketch, Fig. 1, as objectionable. Now why should that give good results in marine practice if it is bad in locomotive practice? May it not be, as I have said, that this method of getting the relief above and below is a good method, while the method that Mr. Quereau has been employing is a bad one?

At an important roundhouse of which I know it is the practice to fit up the main crank pin bushings in this way, putting in a thin liner top and bottom and boring out the brass 1-64th of an inch plus the thickness of the thin liner, larger than the size of the crank pin, then taking out the liners the bushing is keyed down hard on the crank pin. This method has given good satisfaction as far as I know, and I would like to know the experience of others with this or other methods.

THE SECRETARY: Mr. Delano has referred to marine engineering, but the rods of marine engines generally stand vertical, whereas the rods of locomotives are horizontal, and the entire weight of the back end of the main rod, which is generally quite heavy, is carried on the pin. It is quite unusual to find a horizontal stationary, of 1500 horse power, running 300 revolutions per minute.

MR. P. H. PECK (C. & W. I. R. R.): The experience I have had with locomotives differs from what Mr. Delano says is marine practice. I always measure the pin with the thin liner between the caliper and the pin, then put the brasses solid together and bore out the brasses larger than the pin by the thickness of the liner, then key the brass solid, so that they are perfectly circular. In a word, bore the brass 1-32 of an inch larger than the pin, but key the brass solid, so that there is no chance to wear on the straps; if the brass wears on the strap it soon becomes loose and is of no value to hold oil.

MR. R. D. SMITH (C., B. & Q. R. R.): Mr. Chairman, I have had some little experience with trying to make the back end of the

main rod brasses run cool, and our practice for sometime has been as outlined by Mr. Delano. Our practice in treating a brass for the back end of a main rod that has given trouble would be to reduce the brass so as to make the bore smaller, then put a piece of thick tin between the halves and bore the brass 1-64th inch larger than the pin, plus the thickness of the tin. When we take out the tin after boring, each brass has a clearance top and bottom and a good crown bearing without much filing or scraping. This method does away entirely with the filing of which Mr. Quereau makes mention as leaving a small bearing surface, and makes the scraping and filing process almost unnecessary. I think that a good bit of the trouble from hot boxes is due to too much fitting and too much scraping, and I believe that the less we do of these, the more perfect bearing we will have between the pin and the brass.

I have seen brasses in marine practice treated as Mr. Delano says, particularly main shaft bearings. Now it is almost impossible to do very much fitting on a main shaft bearing, possibly 14 or 16 inches in diameter, and in order to overcome that, they usually bolt the halves of the box together with about a quarter inch liner between them, then they bore the box the size of the shaft, plus the quarter inch of liner and perhaps $\frac{1}{32}$ -inch more for slack. The result is that when the liners are taken out the boxes are brought solidly together, and they have a good crown bearing without any scraping or fitting whatever. I think that some of Mr. Quereau's trouble was due to too much filing and fitting.

MR. A. E. MANCHESTER (C., M. & St. P. R. Ry.): I was waiting for the road that has hot pins to tell about them, then the rest of us could make a more satisfactory talk. If the hot pins which Mr. Quereau describes all occurred after the brasses had been fitted, the method of fitting might have had something to do with causing the heating. I have observed that this is not always the case, and that many times the pin that gives trouble has run sometimes for months in a perfectly satisfactory condition, and some night or some day it gets warm and gives trouble. Now I apprehend that the brass, under these conditions, had assumed very much the shape that is shown in Fig. 2 at the time it gave the trouble, although I see no objection whatever to that method of fitting, other than this: I have always believed it advisable never to bevel the way from the oil hole; that with a square shoulder fit from the oil reservoir the specks of dust

were less liable to be drawn in on to the bearing in position to scratch the pin. One of the best things in the paper is the suggestion in regard to stopping the use of valve oil. I believe the use of valve oil, or the heavy oils, is the cause of more heating of bearings of locomotives than anything else, and such oils should not be used at any time on the machinery of the locomotive until the bearings get hot, then these heavy oils may be of some benefit to assist in cooling the bearing. But as soon as the engine arrives at the terminal station and the opportunity is had for readjusting the bearing, the valve oil should be removed. I believe that valve oil is not a good thing to use on cool bearings. There are numerous other causes that lead to hot rod bearings. I notice there is no reference made to the material in the pin. In my judgment the material of which the pin is made has considerable to do with the bearing heating. The style of the strap and the method of holding the brass solid in its place has much to do with the heating of the brass. I believe that most modern engines are not equipped with the old rod key. There is a great improvement over the old methods where a brass would be forced out of shape by the pressure of the key driven against the saddle.

Whether or not solid or babbitted bearings are preferable, I must say that our experience has led us to prefer the babbitted bearings. We find that wherever we use babbitt for bearings we have less trouble from heating than where we use the solid bearings, whether it be in the rod bearings or elsewhere.

MR. M. E. RAPP (C., M. & St. P. Ry.): Mr. President, I have had a good bit of experience with hot bearings, and in fitting up rod brasses, and I find we have better success with the main rod brasses if they are bored to the size of the pin and then scraped to fit the pin and side rod brasses 1-32-inch larger than the pin; solid rod brasses we generally bore 1-32-inch larger than the pin. I find, very often, that a brass gets heated while the locomotive is going up hill rather than going down. The pin has not been lubricated enough to climb a long hill, and before the engine gets to the top, the pin has become warm and gets hot going down the other side. The engineer may think that the heating started while drifting down the hill, but he made a mistake; the heating is done generally while going up the hill on long pulls with heavy trains. For lubrication, I think that grease is much better for rod brasses than oil. We find by

experience that grease prevents the dust from getting around the bearings and gives much better results.

MR. WM. FORSYTH: Mr. President, I think as a rule that main pin bearings are fitted too tightly, especially on large engines and on new engines, and the best way to get a clearance is to bore out instead of filing, by putting in liners, as has been described. In boring out, a clearance is provided top and bottom. That is different from what Mr. Quereau recommends. For my part I am unable to understand how a main pin can wear a cavity in the bearing smaller than its diameter, as described in the paper, and as Mr. Quereau's paper is not thoroughly understood, it would be well to ask him to close the discussion by a written discussion, explaining his illustrations and adding some figures which would give the diameter of the pin and the diameter of the clearance circle he has indicated here.

MR. PECK: Mr. Manchester spoke about the kind of oil; I think there is a great deal to be said about the kind of cup used. With a needle filler cup a thin oil can be used, but with a plunger cup a thicker oil can be used. In climbing a long hill, at a speed of four or five miles an hour, there is not velocity enough to throw the oil in the needle cup to the top of the needle. I have always had better success in running main rods with the thin oil than with the heavy oil and the plunger cup.

MR. STEWART: I have not had a great deal of personal experience in this matter, but some facts have come under my observation which have a bearing on the subject. I remember that on one of the roads with which I was connected we were bothered at one time with a large number of hot pins, and it was soon found that the worst cases of hot main pins were on the most crooked portion of the line, and in following the matter closely we finally came to the conclusion that these hot main pins were probably due to the rolling of the engine while running rapidly over the crooked portions of the line, the tendency of the main pin being to hold the back end of the main rod rigidly, and the tendency of the cross-head pin being to hold the front end of the main rod rigidly. We thought that an attempt to ease off the bearing on the main pin, would be a very large undertaking, owing to the extent of the surface involved and the fact that we would have to ease off considerably on the top and bottom and inside and outside in order to get any relief; but we left the main pin and eased the cross-head pin fit, and got relief much more

easily, because the cross-head bushing was not more than half as wide as the main pin bearing. Besides this, the work at the cross-head end of the main rod is concentrated on the front and back of the pin, the top and bottom has nothing to do, practically, and therefore by easing off the bushing of the front end of the main rod, top and bottom and on each side, we immediately get the desired relief and were able to leave the fit of the brass at the back end of the main rod unchanged. This experience rather opened our eyes, and led to quite a general change in practice, and the result was a reduction in the number of hot main pins. After that, when we found hot main pins we gave our first attention to the fits at the front end of the main rods, rather than the fits at the main pins.

MR. F. H. CLARK (C., B. & Q. R. R.): It seems to me rather strange that the main rod bearing, shown in Fig. 1, should have caused trouble while the locomotive was drifting. The rod, as explained by Mr. Quereau, weighs about 422 pounds. With a 20-inch piston and 200 pounds pressure, the load on the main pin is about 60,000 pounds, or about 140 times as much as when drifting. Now the bearing area, when drifting, is certainly not reduced to such an extent as to offset the difference in pressures, and it looks to me as though there may be something in the suggestion made by Mr. Rapp, that is, that the trouble originates in going up hill. It may be possible that in this case the bearing gets nicely heated in going up hill, but that the trouble is not very noticeable until the engine has passed the summit and is drifting down hill.

THE SECRETARY: It too frequently happens that the pressure per square inch on the pins is not considered when designing the pins; the pins are designed for strength, and whether the size selected is based upon calculations for strength or upon experience in breakage, it will be very easy to fall into the error of not providing surface sufficient to bring the pressure per square inch within allowable limits for wear. In calculating pins, either for strength or for bearing surface, the diameter of the cylinder should be taken at about one inch greater than the normal diameter, and the boiler pressure at ten pounds greater per square inch than the normal; the former because the cylinders will wear to a diameter larger than the normal; and the latter, because steam gages are not always exact, and because a good (?) fireman can frequently fire to carry ten pounds more on the boiler, on a hard pull, than that at which the pop is set.

(A copy of the foregoing discussion was sent to Mr. Quereau, and he prepared the following reply in writing):

MR. C. H. QUEREAU (D. & R. G. R. R.): I am considerably surprised at the very evident incredulity shown in accepting the statements made in my "Notes on Hot Main Pins," and can explain it only on the assumption that the paper was not clearly written or was not carefully read. It would seem but fair to assume that I would be in possession of all the facts in the case before publishing them, and would have no occasion to misrepresent them after spending eight or nine months in investigating the subject and in experimenting. Please accept my assurance that the facts as given are correct, though the reasoning may not be.

I am impressed that the conditions under which these engines work are not fully appreciated; west bound we have a heavy opposing grade for fifty-two miles, during which distance we have had scarcely a hot main pin, these hot pins usually developing in from ten to thirty miles after the train has started on its down-hill drift of sixty-eight miles. On east bound trains the facts have been essentially the same, the hot pins occurring after having drifted from ten to thirty miles of the fifty-two. A careful personal investigation, and a number of interviews with engineers, convinced me that the pins were in good condition on reaching the top of the hill. I therefore felt justified in drawing the conclusion that the main pin fit was such as to cause no trouble while working steam, but was not suitable for drifting such long distances. I believe the results, based on this assumption, fully vindicate the correctness of the conclusion.

It seems to me there is no justifiable parallel between marine and locomotive main pin practice, because there is practically no drifting with marine engines, and the paper under discussion refers mainly to main pin fits which will not run hot where there are long hills to coast. For the same reason there seems to be no parallel between the conditions under which the engines at the "important roundhouse" work, and those to which I have referred, because the former do but little drifting, as they run between Chicago and Burlington over a practically level road.

I do not question that the method of fitting main pin brasses, as described by Mr. Delano and Mr. Smith, is good practice, but it does not therefore follow that the method shown in Fig. 1 of the paper is good, as there is a radical difference between the two. By

their method the bore of the brass is a part of a true circle in each half, while that shown in Fig. 1 gives parts of three circles in each half. This may be seen in Fig. 3, which is an exaggeration of Fig. 1, and also shows how, when the engine is drifting, the bearing is practically confined to the points A.

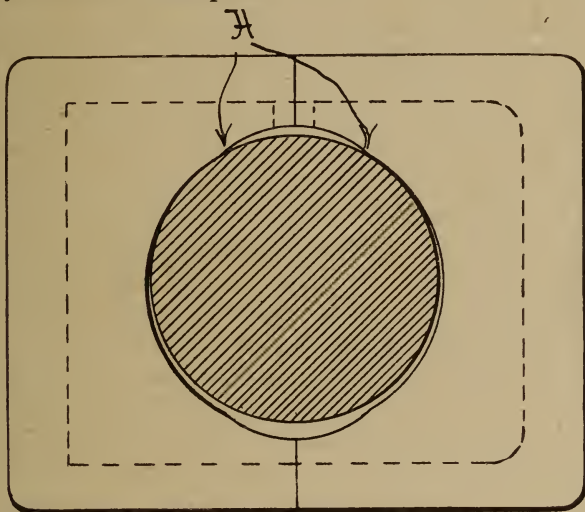


FIG. 3

Mr. Forsyth is in error in assuming that the main pins to which I referred wore a fit smaller than their diameter. The cavities to which he probably refers were filed out in fitting the brasses.

Our experience has been the same as Mr. Stewart's as regards the importance of making the wrist pin fit a rocking one to allow for the rolling of the engine on curves. This is our standard practice.

Mr. Clark has made the mistake of assuming that 422 pounds is the total weight of the main rod. It is the weight on the main crank pin caused by the back end of the main rod. If we assume that the bearing on the main pin, at the points A, is only one-half square inch, it will easily account for such a bearing running hot under the pressure of 422 pounds, or 844 pounds per square inch. It is not probable that the pressure was as great as this, but the above assumption is made to illustrate the point I intended to make clear in the paper.

In conclusion, my principal aim in writing the paper was to call attention to the fact that a main pin fit which would run successfully on

a comparatively level road, would not necessarily do as well where there was considerable drifting. The facts which came under my observation were as follows: For more than a year our high speed engines in passenger service gave considerable trouble by running hot when coasting. After a number of unsatisfactory changes and much experimenting with oil cups, oil, babbitted and unbabbitted brasses, the main pin fit was changed from that shown in Fig. 1 to that illustrated by Fig. 2, and, with the same pins, the same brasses, the same engineers, the same oil and oil cups our engines are now giving practically no trouble from hot pins, notwithstanding the fact that the speed has been increased and a car added to the train since the new fit was adopted. For the first four months of 1898, when the fit shown in Fig. 1 was used, the delays caused by hot main pins were one for each 6,400 engine miles, and one hour's delay for each 16,226 engine miles. During the first four months of 1899, during which time the fit illustrated by Fig. 2 was used, the record of delays due to hot main pins was one delay for each 34,720 miles and 130,200 miles for one hour's delay. A very decided improvement both in the number of delays and the length of time of each delay. It strikes me that this is a clear demonstration of the fact that the fit shown in Fig. 2 is better than that in Fig. 1 for the conditions under which these engines are working. As to whether the line of reasoning which resulted in this successful issue is logical or not, I leave for each to decide for himself.

THE PRESIDENT: If there are no other remarks we will proceed to the closing exercise, which is the last of the year, the election of officers for the coming year. The officers to be elected are a president, first and second vice-presidents, treasurer, two directors, and three trustees of the library, the chairman of which is a director. It is necessary to have two tellers, and I will appoint Mr. Peter H. Peck and Mr. R. D. Smith as tellers.

The rule governing the election of officers is to take an informal ballot first, and the three receiving the highest number of ballots are balloted for in the formal ballot.

An informal ballot for president was taken, the result of which was announced as follows by the President:

Mr. Brazier, 21.

Mr. Manchester, 7.

Mr. Hetzler, 7. Balance scattering.

It was moved by Mr. Peck, and seconded that the Secretary be authorized to cast the unanimous ballot of the Club for Mr. Brazier as president. (Carried.)

THE PRESIDENT: Mr. Brazier, you are elected president for the club year of 1899 and 1900.

MR. BRAZIER: Mr. Chairman and members of the Western Railway Club, I want to thank you for this honor, but it will be impossible for me to accept the office. Circumstances which I cannot control will take me away from Chicago, consequently I cannot be here to attend the meetings, much as I would like to attend. During my connection with the Western Railway Club I have met with so many honors from your hands, by being elected vice-president and by other positions you have given me, that I feel that you are all brothers and friends to me, and I regret the necessity of leaving Chicago, but a man who holds an official position is something like a fish, you cannot know where he is, as a rule. I want to thank you sincerely and truly for this honor, and I would be very glad to remain here and hold the position.

MR. PECK: Mr. President, under the circumstances I will move that Mr. Brazier's declination be accepted and that we proceed to the election of a president. (Seconded, and carried.)

A formal ballot for president was taken, the result of which was announced as follows:

Mr. Hetzler, 25 votes.

Mr. Manchester, 24 votes.

On motion of Mr. Manchester the vote for Mr. Hetzler was made unanimous, and the Chairman declared Mr. Hetzler duly elected as President of the Western Railway Club.

Proceeding in regular order the following were nominated on informal ballot and elected on formal ballot:

Mr. A. E. Manchester, First Vice-President.

Professor Wm. F. M. Goss, Second Vice-President.

Mr. Peter H. Peck, Treasurer.

Mr. R. D. Smith, Director.

Mr. B. Haskell, Director.

Mr. F. W. Sargent, Director, and Chairman Library Trustees.

Mr. F. A. Delano, Library Trustee.

Mr. Wm. Forsyth, Library Trustee.

ADJOURNED.

The newly elected Board of Directors met immediately after the Club meeting and elected Mr. F. M. Whyte, as Secretary.

APPENDIX A.

REPORT OF THE SECRETARY AND TREASURER.

CHICAGO, May 16, 1899.

To the Directors and Members of the Western Railway Club:

Your Secretary respectfully submits the following as a report of the work accomplished by the Club during the club year of 1898-99.

It will not be necessary to inform you that, as a whole, the papers presented during the year just ending have been very well received by members of the Club and by others who are interested in the subjects treated. The papers have added much to the information on the subjects considered, and it is believed that several of them will be referred to frequently in years to come.

Eleven papers were read before the Club and discussed by the members; ten subjects of general interest were discussed, and two committees presented reports which were discussed.

The papers presented and discussed were as follows :

Heating Large Railroad Shops and Stations	Mr. G. W. Scott
The Adoption of a Standard Knuckle.....	Mr. Peter H. Peck
The Framing of Cars.....	Mr. F. M. Whyte
Tests of Coal for Locomotives.....	Mr. Wm. Garstang
Tests of Locomotive Boiler Coverings.....	Mr. Robert Quayle
The Uses of Compressed Air about Railway Shops.....	{ Mr. J. W. FitzGibbons
	{ ...Mr. Willis C. Squire
	{Mr. B. Haskell
Compound Locomotives on the Northern Pacific Railway..	Mr. Edwin M. Herr
High Speed Passenger Locomotives	Mr. Clement F. Street
Notes on Hot Main Pins.....	Mr. C. H. Quereau

The subjects discussed were as follows :

Economy of, and Limitations in, Running Locomotives Long Distances.

Is it Practical, Safe and Economical to Use Spliced Air Brake Hose?

What is the Best Disposition to be made of the Exhaust from the Air Pump?

Improved Methods of Handling Ashes from Locomotives.

Improved Methods of Drying and Handling Sand for Locomotives.

Grates for Locomotives Supplied with Illinois Grade of Coal.

Height of Drawbars.

Knuckles for M. C. B. Couplers.

Better Design of Flat Cars.

The Use of Water on Hot Journals.

Committees have reported on the following subjects :

Recommended changes in the Rules of Interchange.

A Standard Knuckle for the M. C. B. Coupler.

The attendance has been very large at most of the meetings, but the attend-

ance gives no indication of the number of members of the Club. There have been added during the year to the roll of membership 130 names; there were suspended for non-payment of dues 65 members; there were 39 withdrawals; and we have lost by death 6 members. The net gain in membership has been 20, and the Club has at this date 906 members, which is probably the largest number in the history of the Club. The list is kept closely pruned, and the only members owing the Club and who receive the Proceedings are those owing for the current year; those owing for two years' dues do not receive the Proceedings, and as soon as a member becomes delinquent to the amount of \$6.00 his name is erased from the membership list.

The annual banquet was dispensed with this year, for reasons which have been explained to you, and partly on this account, and partly on account of the increase in income, it has been possible for the Club to pay all the running expenses of the library. These were paid previously out of a fund raised by subscription. It seems possible, also, to give to each member in good standing the Proceedings of the year, bound in one volume, and this the Directors and the Club have authorized. The binding will be uniform with that of the Proceedings of the M. C. B. and M. M. Associations.

Having had charge of the funds of the Club since April 18, 1899, it is proper to include a report of the financial condition of the Club at this date, the previous Treasurer, Mr. Cloud, having made his last report to the Directors at their meeting on April 18, 1899. The report is as follows:

RECEIPTS SINCE MAY 17, 1898.

On hand at date of Annual Report, May 17, 1898	-	-	\$1,052.62	
Total receipts since that date	-	-	5,730.30	\$6,839.02

DISBURSEMENTS.

Acct. printing, electrotyping and mailing Proceedings	-	\$2,320.83	
Stenographic work	-	190.00	
Salary of Secretary	-	325.00	
Cost of Advertisements	-	673.28	
Proceedings from other Railway Clubs	-	967.46	
Library: salary Librarian, rent and binding	-	339.45	
Miscellaneous office expenses	-	147.81	\$4,963.83
Cash balance on hand May 16, 1899	-	-	\$1,875.19

THE BILLS RECEIVABLE ARE AS FOLLOWS:

From Advertising	-	\$ 515.00
“ Dues	{ \$4.00 -	316.00
“	{ 2.00 -	246.00
“ Sale of Proceedings	-	15.00
“ Other Clubs	-	91.89
Total	-	\$1,183.89

The bills in hand payable amount to \$389.24, and these will be paid at once.

The above shows that the financial condition has improved considerably during the year, and that whereas the income increased \$1,816.88, the expenses increased \$1,030.41. The items which have contributed most to the increase in expenses are: The cost of Proceedings from other clubs, the increase being \$758.71; the printing, increase, \$371.18; the library, increase, \$339.45. These increases have been offset partly by decreases, the larger items being the saving on the banquet, \$288.50; the salary of the Secretary, \$124.76, and the stenographic work, \$70.00.

Of the bills receivable, those for advertising, sale of Proceedings, and due from other clubs, will be collected; of the amount due from members, \$562.00, probably \$350.00 may safely be written to profit and loss, and this will leave the amount of bills receivable which are reasonably certain of collection, \$833.89, or a total good assets, disregarding the library property, \$2,709.08.

Respectfully submitted.

F. M. WHITE, Secretary.

APPENDIX B.

REPORT OF LIBRARY TRUSTEES.

CHICAGO, May 16, 1899.

To the Officers and Members of the Western Railway Club:

Your Trustees of the David L. Barnes Library beg to submit the third Annual Report of the condition of the Library, which has been open for the use of members and other visitors since January 1, 1897, or almost two and one-half years.

The Library is still maintained at 1750 Monadnock Building under the care of the librarian. The same arrangement with the *Railroad Gazette* for the rent of the library room as noted in our report a year ago, has been continued, part of the rent being paid by the Club and part contributed by the *Railroad Gazette*. Our present arrangement continues in force until September next.

Since our last report forty-two volumes of periodicals and transactions have been bound. The proceedings of all the other railroad clubs for 1893, 1897 and 1898 were included in the volumes bound this year, which gives the Library complete files of proceedings of all the railroad clubs from and including 1894. Three hundred fifty (350) books, copies of club and society proceedings, pamphlets and catalogues have been given to the Library, which, in addition to the volumes bound, makes a total accession of three hundred ninety-two (392) books, pamphlets and catalogues to our collection.

About two hundred twenty-five (225) persons have visited and used the Library since our last report, an increase of twenty-five (25) over the year before.

As more shelf room became necessary, shelves have been added to our bookcases, making room for two hundred volumes, and enabling the Library to take care of the accessions above noted.

F. W. SARGENT,

WM. FORSYTH,

(Absent and did not sign) A. M. WAITT,

Trustees

LIBRARY ACCESSIONS.

The Trustees of the Library wish to acknowledge, with thanks, the following donations to the Library, received since Jan. 1, 1899:

- Mr. F. R. Hutton, Secretary: Transactions of the American Society of Mechanical Engineers, Vol. XIX, 1898.
Also, Constitution and List of Members, Jan. 1, 1899.
- Mr. E. E. R. Tratman: Proceedings Roadmasters' Association, 1896 and 1897. Proceedings American Society of Civil Engineers for parts of 1897 and 1898. Report Railroad and Warehouse Commission of Illinois for 1897. Rail Joints and Steel Rails. By C. P. Sandberg. Inst. C. E. (Eng.) Pamphlet.
Steel Rails. By C. P. Sandberg. Pamphlet.
Heavier Steel Rails. By C. P. Sandberg. Pamphlet.
The Cattle Guard Problem. By Benjamin Reece.
Railway Accident Returns (Eng.) 1897.
Prospectus Great Northern Railway. (Eng.)
Also, 21 copies back issues of Railroad Club Proceedings.
- Mr. J. C. Whitridge: Mayor's Message and Twenty-Second Annual Report of Department of Public Works, Chicago, 1897.
- U. S. War Department: Tests of Metals, 1897.
- Prof. William G. Raymond: Copy of Lecture on "The Beginning of a Railroad."
- Mr. W. L. Derr: Block Signal Operation, 1897.
- The Railway Age, by Mr. H. P. Robinson, President: "Repairs of Railway Car Equipment," by H. M. Perry, 1899.
- Mr. John N. Reynolds: The Electric Railroad List. Jan.-Mar., 1899.
- Mr. C. B. Conger: "Air Brake Catechism." Revised edition, Nov. 1898.
Also, Reports of Proceedings of Traveling Engineers' Association, 1893-1897. Cloth.
- Mr. J. B. Dickson, Secretary: Proceedings of the Roadmasters' Association, 1898.
- Baldwin Locomotive Works: Record of Recent Construction. Nos. 10, 11 and 12.
- B. F. Sturtevant Co.: "Mechanical Draft." Cloth. Illus.
- Mr. P. M. Kilroy, Secretary: Proceedings Association Railroad Air Brake-men, 1898.
- Mr. L. R. Pomeroy: Paper on "Treatment of Steel for Car Axles," read before the Engineering Society of Columbia University, 1898.
- Mr. Charles Warren Hunt, Secretary: Constitution and List of Members American Society of Civil Engineers, 1899.
- Mr. Charles McShane: "The Locomotive Up To Date." Cloth. Illus., 1899.
- The John Crerar Library: Fourth Annual Report, 1898.

MISCELLANEOUS DUPLICATES IN THE DAVID L. BARNES LIBRARY FOR SALE OR EXCHANGE.

American Engineer, The, for years 1887 and 1888.

American Engineer, Car Builder and Railroad Journal, from Jan., 1893 to Dec., 1895, Vols. LXVII to LXVIX inclusive, complete with Indexes. Also from June, 1896, Vol. LXXX to Dec. 1897, Vol. LXXXI inclusive with Indexes.

American Railway Master Mechanics' Association:

Proceedings for 1894. Also, Vol. 30, 1897.

Report of Committee on The Apprentice Boy.

" " " " Arbitration Cases Nos. 378 to 381, 1897.

" " " " " " " " 396 to 42, "

" " " " Counterbalancing.

" " " " Cylinder Bushing.

" " " " Driving Box Wedges.

" " " " Exhaust Pipes and Steam Passages.

" " " " Hub Liners.

" " " " Laboratory Tests of Brake Shoes.

" " " " Lubrication of Cars.

" " " " Reciprocating Parts.

" " " " Thickness of Engine Truck Wheel Flanges.

" " " " Slide Valves. 1896.

" " " " Standard Size of Boiler Tubes.

" " " " Steps and Handholes.

Atmospheric Resistance and Its Relation to Speed of Railway Trains. By F. U. Adams, 1892.

Boiler Maker, The, Dec. 1897.

Bulletin of the Bureau of American Republics, Monthly, Dept. 1898.

Calibration of a Worthington Water Meter. By John A. Laird. Paper before Am. Soc. Mech. Engrs., 1896.

Central Railway Club Proceedings. Various issues from April, 1894, to March, 1899.

Classification and Catalogue System for an Engineering Library, A. By F. R. Hutton. Paper before Am. Soc. Mech. Engrs. 1896.

Compound Locomotives. Improved Lindner System. Pamphlet, 1891.

Counterbalance in Locomotive Drive-Wheels. An experimental study of their effect upon the pressure between wheel and rail. By Wm. F. M. Goss. Paper read before Am. Soc. Mech. Engrs., 1894.

Digest of Physical Tests, Jan., 1896. Vol I., No. 1.

Diseases of the Air Brake System. By Paul Synnestvedt. 1894.

Down Draft Furnace for Steam Boilers, The. By William H. Bryan. Paper before Am. Soc. Mech. Engrs., 1895.

Effect of Brakes Upon Railway Trains. By Capt. Douglas Galton. 1894.

- Electric Locomotives. By David L. Barnes. 1896.
- Electric Propulsion, A New System of. By H. Ward Leonard. Am. Inst. Elec. Engrs., 1892.
- Engineering Magazine. Aug., Sept. and Nov., 1897.
- Geology and Hydrology of the Great Lakes, Notes About The. By P. Vedal, West. Soc. Engrs.
- International Railway Congress. Fifth Session. London, 1895. Reports Nos. 1 to 12 and 29 to 35 inclusive.
- Improvement of Railway Track and Street Railway Track. By E. E. R. Tratman. Paper before Am. Soc. Civil Engrs.
- Journal Association of Engineering Societies. Aug. to Dec. 1893, Vol. XII., with Index; also Vol. XIII, 1894, except May and Aug. missing; also Vol. XIV, 1895, complete with Index, and Jan., July, Oct., and Nov., 1895; also Aug. and Sept., 1897.
- Journal, Western Society of Engineers. Vol. II, No. 2, April, 1897.
- Locomotive, The. Published by the Hartford Steam Boiler Inspection and Insurance Co. Odd numbers from Jan., 1896 to March, 1899.
- Locomotive Engineering. 1896 and 1897 complete, except index to 1897.
- Long Distance Transmission for Lighting and Power. By Charles F. Scott. Am. Inst., Elec. Engrs. 1892.
- Malleable Cast-Iron, Manufacture and Properties of. By H. R. Stanford. Am. Soc. Civil Engrs., 1895. 2 copies.
- Master Car Builders and Master Mechanics, Advanced Reports. 1897.
- Memphis Bridge, The Continuous Superstructure of. By Geo. S. Morison. Paper before the Am. Soc. Civil Engrs. Section of the Engineering Congress at Chicago, 1893. 3 copies.
- New England Railroad Club Proceedings. Various issues from March, 1894, to May, 1897.
- New York Railroad Club Proceedings. Various issues from May, 1891, to Dec., 1898.
- Northwest Railway Club Proceedings. Various issues from Dec., 1894 to Jan., 1899.
- Official Railway List. 1890.
- Piles, Supporting Power of. By Franz Kreuter. Inst. C. E. (Eng.) 1896.
- Proceedings Am. Soc. Civil Engrs. April, May, Aug., Sept., Oct., Nov., Dec., 1897, and Jan., Feb., March, April, May, Sept., and Dec., 1898.
- Proceedings of the Board of Trustees of the Sanitary District of Chicago. Odd numbers from Nov. 14, 1894 to Sept. 22, 1897.
- Proceedings Fifth Annual Convention Association of Railway Superintendents of Bridges and Buildings. 1895.
- Proceedings Fourteenth Annual Convention of the Roadmasters' Association of America. September, 1896.
- Proceedings of the Master Car Builders' Association. Vol. 30, 1896.
- Proceedings of the Association of Railroad Air Brakemen. Second Annual Convention, 1895. 2 copies.
- Proceedings of the Texas Railway Club. April and Sept., 1896.
- Proceedings of the Western Foundrymens' Association. May, 1894.

- Railroad and Engineering Journal. 1880 and 1888, except Jan., Aug., and Sept., 1887, and Feb., 1888.
- Railway Train Lighting. By A. H. Bauer. Am. Inst. Elec. Engrs., 1892.
- Report of State Board of Health of Connecticut. 1896 and 1897. 2 Vols.
- Science. From Jan., 1895 to June 1898. Almost complete.
- Series Electric Traction. By Nelson W. Perry. Am. Inst. Elec. Engrs., 1892.
- Speed and Acceleration Tables. Reprinted from *Railroad Gazette* of Oct. 31, 1890.
- St. Louis Railway Club Proceedings. Various issues from Sept., 1896 to Aug., 1898.
- Statistics of Railways in the United States. Fourth Annual Report of the Interstate Commerce Commission. 1891.
- Steel, Physical Properties of Acid Open Hearth as compared with Carbon Steel of Similar Tensile Strength. By H. H. Campbell. Am. Soc. Mech. Engrs. 1895.
- Steel Skeleton Construction in Chicago. By E. C. Shankland, Inst. Civil Engrs. (Eng.) 1896.
- Southern and Southwestern Railway Club Proceedings. Various issues from Jan., 1893, to Nov., 1898.
- Testing Iron and Steel and Other Metals, Report of Board on. Vol. I, 1881.
- Tests of a Compound Locomotive. Baldwin Locomotive Works. 1891.
- Tests of Compound Locomotives. Baldwin Locomotive Works.
- Test of Johnstone Compound Locomotive on Mexican Central Ry. By David L. Barnes and F. M. Whyte. 1892.
- Tests of Metals, made at Watertown Arsenal, Mass., 1883, 1884, 1891, and 1892. Four volumes.
- Tests of a Single-Expansion Ten-Wheel Locomotive on the B. & O. R. R. By David L. Barnes. 1891.
- Transactions American Society of Mechanical Engineers. Vol. XVI, 1895; Vol. XVII, 1896; and Vol. XVIII, 1897. Complete with indexes. Paper.
- Vauclain Four-Cylinder Compound Locomotive on the South Side Elevated R. R., Chicago, Cylinders and Valves of.
- Vauclain System of Compound Locomotives. Pamphlet. 1896.
- Wisconsin Engineer. Jan., 1897. Vol. I, No. 3.
- Mr. Edward A. Moseley, Secretary: Copies of the Tenth, Eleventh and Twelfth Annual Reports of the Interstate Commerce Commission for years 1896, 1897 and 1898. Also, Statistics of Railways in the United States, 1897. Also, Preliminary Report of the Income Account of Railways for the Year ending June 30, 1898.
- From the Secretary: Annuaire and List of Members, Societe des Ingenieurs Civils de France. 1899.
- Mr. E. E. R. Tratman: Twenty-three copies of Papers and Abstracts of Foreign Papers. Institution of Civil Engineers (England).

THE DAVID L. BARNES LIBRARY.

SPECIAL NOTICE! The David L. Barnes Library of this Club, at 1750 The Monadnock, Chicago, is open for the use of members and their friends, and we hope it will be used freely. It is open on week days from 9 a. m. to 5:30 p. m., except on Saturday, until 3 p. m. Books must not be removed from the Library, but the librarian will assist visitors in finding information and will promptly reply to letters from out-of-town members desiring information from the Library. Donations of books and technical publications will be gratefully received.

TRUSTEES OF THE LIBRARY.

List of duplicate copies of the Proceedings of the Western Railway Club which are in the David L. Barnes Library and are for sale or exchange:

1888—Sept. and Oct. (bound in one).

1889—Oct., Dec.

1890—Feb., Sept., Oct., Nov., Dec.

1891—Jan., Mar., Apr., May, Oct., Nov.

1892—Jan., Feb., Apr., May, Sept., Nov., Dec.

1893—Two complete volumes; also single copies of Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

1894—Jan., Mar., Apr., May, Oct., and Index of subjects discussed by the Club.

1895—Jan., Apr., Sept., Oct., Nov., Dec.

1896—One complete volume, also single copies of Jan., Mar., May, Sept. Nov., Dec.

1897—Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec., also two complete volumes.

1898—Jan., Feb., Mar., Apr., May, Sept., Oct., Nov., Dec.

Correspondence relating to the Library, donations of books, periodicals, etc., for the files, or duplicates sent for exchange should be addressed to H. de K. Woods, Librarian, 1750 Monadnock, Chicago.

INDEX.

A

Address, Schroyer, C. A.:

Reply to Mr. Wm. Thow..... 35

Address, Thow, Wm. 34

B

Barr, J. N., Discussion:

Better design of flat car 250, 251

Compound locomotives.....291, 299, 309, 311

Handling cinders from locomotives89, 90, 93

Heating large railway buildings..... 11

M. C. B. Coupler. 350, 354, 356

Uses of compressed air about railway shops.....233, 239, 344, 247

Use of water on hot bearings.....253, 255

Brazier, F. W., Discussion:

Better design of flat cars 251

Handling sand for locomotives..... 99

Uses of compressed air about railway shops..... 242

Use of water on hot bearings.... 253

Breckenridge, L. P., Discussion:

Tests of coal for locomotives.....138, 147, 148

Bryan, H. S., Discussion:

Handling sand for locomotives 94

C

Cardwell, J. R., Discussion:

The framing of cars ... 83

Clark, F. H., Discussion:

Hot main pins..... 391

Clifford, C. J., Discussion:

Uses of compressed air about railway shops..... 246

Cloud, J. W., resignation as Treasurer..... 343

D

Deems, J. F., Discussions:

Compound locomotives..... 303, 308

Long runs for locomotives.... 23

Handling cinders from locomotives..... 91

Height of drawbars 212

High speed passenger locomotives..... 338

Tests of locomotive boiler coverings.....	193
Using water on hot bearings.....	254
Use of compressed air about railroad shops.....	234, 241
Delano, F. A., Discussions:	
Better design of flat car.....	248, 251
Handling cinders from locomotives.....	90
Height of drawbars.....	211
Hot main pins.....	386
M. C. B. coupler.....	50, 54, 213, 219, 347, 355, 361
Tests of coal for locomotives.....	135
Tests of locomotive boiler coverings.....	189, 207
Uses of compressed air in railroad shops.....	245
Discussion of Papers:—Adoption of a standard knuckle.....	
Curtis, H. R.....	51
Delano, F. A.....	50, 54
Giroux, G.....	44
Hubbell, Ira C.....	43
Mackenzie, John.....	49
Payson, G. S.....	52
Peck, P. H.....	49
Schroyer, C. A.....	53
Stout, C. F.....	49
Waite, A. M.....	48
Compound Locomotives on the Northern Pacific Railway, 282-316:	
Barr, J. N.....	291, 299, 309, 311
Conger, C. B.....	307
Cushing, G. W.....	304
Deems, J. F.....	303, 308
Goss, W. F. M.....	289
Herr, E. M.....	282, 311
Lovell, A.....	289
Manchester, A. E.....	295, 306, 309
Marshall, W. H.....	298, 308
Miller, Robert.....	310
Morris, W. S.....	284
Committee Reports:	
M. C. B. coupler, preliminary report.....	105-110, 213, 219
M. C. B. coupler, final report.....	345-347
M. C. B. coupler, final report discussion.....	347-353
Interchange rules, appointment of committee.....	161
Interchange rules, final report and discussion.....	363-377
Communications:	
Cloud, J. W., resignation as Treasurer.....	343
Goss, W. F. M., resignation as Second Vice-President.....	259
Gunsaulus, F. W., invitation to Armour Institute.....	343

Joint Car Inspection Association.....	113, 210
Niles Tool Works Co., invitation.....	114
Smart, President J. H.....	4
Western Society of Engineers	4
Conger, C. B., Discussion:	
Compound locomotives.....	307
Hot main pins.....	385
Use of water on hot bearings.....	252
Curtis, R. H., Discussion:	
A standard knuckle	51
Cushing, G. W., Discussion:	
Compound locomotives.....	304
Tests of locomotive boiler coverings.....	198
Pomeroy, L. R.....	310
Pratt, E. W.....	310
Smart, R. A.....	303
Soule, R. H.....	300
Street, C. F.....	309, 311
Tratman, E. E. R.....	306
Vaughn, H. H.....	307
Heating Large Railroad Stations and Shops, 10-21:	
Barr, J. N.....	11
Manchester, A. E.....	13, 17, 20, 21
Rhodes, G. W.....	19
Scott, G. W.....	10, 18
Thurtell, B. W.....	12, 21
Waite, A. M.....	10, 16
High-Speed Passenger Locomotives, 333-339:	
Deems, J. F.....	338
Marshall, W. H.....	334
Pattee, J. O.....	333
Smart, R. A.....	336
Street, C. F.....	333, 338, 339
Tratman, E. E. R.....	336
Notes on Hot Main Pins, 385-396:	
Clark, F. H.....	391
Conger, C. B.....	385
Delano, F. A.....	386
Forsyth, Wm.....	390
Manchester, A. E.....	388
Peck, P. H.....	387, 390
Quereau, C. H.....	392

Rapp, M. E.....	380
Smith, R. D.....	389
Stewart, Mr.	390
Whyte, F. M.....	389, 391

Tests of Coal for Locomotives, 130-153:

Breckenridge, L. P.....	138, 147, 148
Delano, F. A.....	135
Ettinger, R. L.....	134
Farmer, G. W.....	133
Gasche, F. G.....	135
Goss, W. F. M.....	131, 148, 150
Manchester, A. E.....	144
Marshall, W. H.....	145, 147
Rhodes, G. W.....	134, 150
Slater, F.....	147
Thurtill, B. W.....	149
Whyte, F. M.....	130

Tests of Locomotive Boiler Coverings, 183-209.

Cushing, G. W.....	198
Deems, J. F.....	193
Delano, F. A.....	189, 207
Gasche, F. G.....	186
Goss, Wm. F. M.....	189, 207
Johnson, W. W.....	196
Marshall, W. H.....	197
Mayr, Chas.....	202
McIntosh, Wm.....	194
Smith, H. E.....	194
Soule, R. H.....	194
Waite, A. M.....	206, 208
Whyte, F. M.....	183, 193, 206

The Framing of Cars, 71-86:

Cardwell, J. R.....	83
Goss, Wm. F. M.....	82
Hatt, W. K.....	76
Hill, Jos. W.....	79
Peck, P. H.....	84
Showers, G. W.....	81
Tratman, E. E. R.....	83
Waite, A. M.....	79, 85
Whyte, F. M.....	71, 85

Uses of Compressed Air about Railway Shops, 233-247:

Barr, J. N.....	233, 239, 244, 246
Brazier, F. W.....	242

Clifford, C. J.....	246
Deems, J. F.....	234, 241
Delano, F. A.....	245
Mackenzie, John.....	241
Morse, Mr.....	241, 243
Otis, Spencer.....	245
Paxton, Thos.....	243, 245
Pflager, H. M.....	241
Pratt, E. W.....	246
Sullivan, C. L.....	239
Whyte, F. M.....	233, 246
Wickhorst, M. H.....	240, 246

Discussion—Committee Reports.

Changes Recommended in Rules of Interchange, 363-377:

M. C. B. Coupler, 347-362.

Barr, J. W.....	350, 354, 356
Delano, F. A.....	50, 54, 347, 355, 361
Fildes, Thos.....	350
Morris, W. S.....	355, 362
Rhodes, G. W.....	355, 356, 361
Schroyer, C. A.....	353
Street, C. F.....	49
Timms, Jas.....	353, 354, 359
Tobey, Mr.....	354

Discussion—Topical.

Better Design for Flat Cars, 248-251.

Barr, J. N.....	250, 251
Brazier, F. W.....	251
Delano, F. A.....	248-251
Smith, Wm.....	248
Stark, F. H.....	250, 251

Grates for Illinois and Iowa Coal, 153:

Manchester, A. E.....	153
-----------------------	-----

Handling Cinders from Locomotive Ash-pans, 86-93:

Barr, J. N.....	89, 90, 93
Deems, J. F.....	91
Delano, F. A.....	90
Hill, Jas. W.....	89
Neuffer, J. G.....	86
Rhodes, G. W.....	90
Smith, R. D.....	92, 93
Tratman, E. E. R.....	88
Whyte, F. M.....	93

Handling Sand for Locomotives, 94-99:

Deems, J. F.	99
Brazier, F. W.	99
Bryan, H. S.	94
Hill, Jas. W.	96, 98
Rhodes, G. W.	96, 100
Smith, R. D.	99
Whyte, F. M.	98

Height of Drawbars, 210-212:

Deems, J. F.	212
Delano, F. A.	211
Peck, P. H.	210
Rhodes, G. W.	211
Smith, R. D.	211

Running Locomotives Long Distances, Economy in, 21-26:

Deems, J. F.	23
Mackenzie, John	21, 22, 23, 26
Manchester, A. E.	22
Rhodes, G. W.	24, 25

Spliced Air Brake Hose, is it Safe and Economical? 27-34:

Manchester, A. E.	33
Rhodes, G. W.	29, 31, 33, 34
Waite, A. M.	27, 30, 31

Use of Water on Hot Bearings, 252-255:

Barr, J. N.	253, 255
Brazier, F. W.	253
Conger, C. B.	252
Deems, J. F.	254
Graham, J. A.	252, 254
Whyte, F. M.	255

What is Best Disposition to be made with Exhaust from the Air Pump?

Goss, Wm. F. M.	55, 61
Herr, E. M.	58, 59, 61
Mackenzie, John	57, 59
Peck, P. H.	55, 56
Pratt, E. W.	61, 62
Quayle, Robert	59, 62
Setchell, J. H.	56, 57
Whyte, F. M.	55, 57, 60

E

Ettinger, R. L., Discussion:

Tests of coal for locomotives.	134
-------------------------------------	-----

Excursion, Report of, to Niles Tool Works Co.	213-215
--	---------

F

Farmer, G. W., Discussion:	
Tests of coal for locomotives	133
Fildes, Thos., Discussion:	
M. C. B. Coupler	350
Fitz Gibbons, J. W., Paper:	
Uses of compressed air about railway shops	221-224
Forsyth, Wm., Discussion:	
Hot main pins	390

G

Garstang, Wm., Paper:	
Tests of coal for locomotives	115, 129
Gasche, F. W., Discussion:	
Tests of coal for locomotives	135
Tests of locomotive boiler coverings	186
Giroux, Gustav, Discussion:	
A standard knuckle	44
Goss, Wm. F. M., Discussion:	
Compound locomotives	289
Disposition of exhaust from air pump	55, 61
Framing of cars	82
Resignation as Second Vice-President	259
Tests of coal for locomotives	131, 148, 150
Tests of locomotive boiler coverings	189, 207
Graham, J. A., Discussion:	
Use of water on hot bearings	252, 254

H

Haskell, B., Paper:	
Uses of compressed air about railway shops	228, 232
Hatt, W. K., Discussion:	
Framing of cars	76
Herr, E. M., Paper and Discussion:	
Compound locomotives on the Northern Pacific Railway ..	261, 282, 311
Discussion: Disposition of exhaust from air pump	58, 59, 61
Hill, Jas. W., Discussion:	
Framing of cars	79
Handling cinders from locomotives	89
Handling sand for locomotives	96, 98
Hubbell, Ira C., Discussion:	
A standard knuckle	43

J

Johnson, W. W., Discussion:

Test of locomotive boiler coverings	196
---	-----

L

Library Accessions	154, 399
Duplicate books for sale	400
Report of trustees.....	398

Lovell, A., Discussion:

Compound locomotives on the Northern Pacific Railway.....	239
---	-----

Luttrell, J. W., Discussion:

Heating large railroad buildings	17
--	----

M

Mackenzie, John, Discussion:

Disposal of exhaust from air pump.....	57, 59
Long runs for locomotives..	21, 23, 26
Standard knuckle.....	49
Uses of compressed air about railway shops.....	241

Manchester, A. E., Discussion:

Compound locomotives.....	293, 306, 309
Grates for Illinois and Iowa coal	153
Long runs for locomotives	22
Heating large railway buildings.....	13, 17, 20, 21
Hot main pins	388
Spliced air brake hose	31
Tests of coal for locomotives.....	144

Marshall, W. H., Discussion:

Compound locomotives	298, 308
High speed passenger locomotives.....	334
Long runs for locomotives.....	26
Tests of coal for locomotives	145, 147
Tests of locomotive boiler coverings.....	199

Mayr, Chas., Discussion:

Tests of locomotive boiler coverings.....	202
---	-----

Members, lists of new.....3, 38, 64, 113, 158, 218, 258, 342, 380

Miller, Robert, Discussion:

Compound locomotives.....	310
Tests of coal for locomotives.....	147

Morris, A. D., Discussion:

Tests of locomotive boiler coverings.....	205
---	-----

Morris, W. S., Discussion:	
Compound locomotives.....	284
M. C. B. coupler.....	355, 362

N

Neuffer, J. G., Discussion:	
Handling cinders from locomotives.....	86
Niles Tool Works Co., invitation to visit works of.....	114

O

Officers—Election of, for 1899–1900.....	394–395
Reports of Secretary and Treasurer.....	396–398
Report of Trustees of Library..	398
Otis, Spencer, Discussion:	
Uses of compressed air about railway shops	245

P

Papers:—Adoption of a Standard Knuckle—Mr. Peter H. Peck	40–43
Compound Locomotives on the Northern Pacific Railway—Mr. Edwin M. Herr.....	261–282
Heating Large Railroad Stations and Shops—Mr. G. W. Scott.....	5–10
High Speed Passenger Locomotives—Mr. Clement F. Street.....	317–332
Notes on Hot Main Pins—Mr. C. H. Quereau.....	383–385
Tests of Coal for Locomotives—Mr. Wm. Garstang	115–129
Tests of Locomotive Boiler Coverings—Mr. Robert Quayle.	162–182
The Framing of Cars—Mr. F. M. Whyte.....	65–71
Uses of Compressed Air about Rail- way Shops.....	{ Mr. J. W. Fitz Gibbons..221–224 Mr. Willis C. Squire....225–227 Mr. B. Haskell.....228–232
Pattee, J. O., Discussion:	
High speed passenger locomotives	333
Paxton, Thos., Discussion:	
Uses of compressed air about railroad shops.....	243, 245
Payson, G. S., Discussion:	
A standard knuckle.....	52
Peck, Peter H., Discussion:	
Disposal of exhaust from air pump.....	55, 56
Framing of cars.....	84
Height of draw bars.....	210
Hot main pipes.....	387, 390
M. C. B. Coupler.....	110
Paper—Adoption of a Standard Knuckle.....	40–43
Discussion.....	49

Pflager, H. M., Discussion:	
Uses of compressed air about railroad shops.....	241
Pomeroy, L. R., Discussion:	
Compound locomotives.....	310
Pratt, E. W., Discussion:	
Compound locomotives.....	310
Disposal of exhaust from air pump.....	61, 62
Uses of compressed air about railway shops.....	246
Proceedings, publishing in book form	159, 160, 161

Q

Quayle, Robert:	
Discussion—Disposal of exhaust from the air pump.....	59, 62
Paper—Tests of locomotive boiler coverings.....	162-182
Quereau, C. H.:	
Paper—Notes on hot main pins.....	383-385
Discussion—Notes on hot main pins.....	392

R

Rapp, M. E., Discussion:	
Hot main pins	389
Reports of Committees:	
Interchange rules	363-377
Adoption of a standard knuckle.....	105-110
Rhodes, G. W., Discussion:	
Handling cinders from locomotives.....	90
Handling sand for locomotives.....	96, 100
Heating large railroad buildings	19
Height of draw bars	211
Long runs for locomotives.....	24, 25
M. C. B. coupler.....	110, 355, 356, 361
Spliced air brake hose.....	29, 31, 33, 34
Tests of locomotive boiler coverings.....	188, 208
Tests of coal for locomotives	134, 150

S

Schroyer, C. A., Discussion:	
Spliced air brake hose.....	33
Standard knuckle	53, 353
Remarks about library.....	39
Reply to address by Mr. Wm. Thow.....	35
Setchell, J. H., Discussion:	
Disposal of exhaust from air pump.....	56, 57

Scott, G. W.:	
Paper—Heating large railroad stations and shops.....	5-10
Discussion—Heating large railroad stations and shops.....	10, 18
Showers, G. W., Discussion:	
Framing of cars.....	81
Slater, F., Discussion:	
Tests of coal for locomotives.....	147
Smart, Pres. J. H.,	
Communication.....	4
Smart, R. A., Discussion:	
Compound locomotives.....	303
High speed passenger locomotives.....	336
Smith, H. E., Discussion:	
Tests of locomotive boiler coverings.....	194
Smith, R. D., Discussion:	
Handling cinders from locomotives.....	92, 93
Handling sand for locomotives.....	99
Height of drawbars.....	211
Hot main pins.....	387
Smith, Wm., Discussion:	
Better design of flat car.....	248
Squire, W. C., Paper:	
Uses of compressed air about railway shops.....	225-227
Soule, R. H., Discussion:	
Compound locomotives.....	300
Tests of locomotive boiler coverings.....	194
Stark, F. H., Discussion:	
Design of flat car.....	250, 251
Street, C. F., Discussion:	
Adoption of a standard knuckle.....	49
Compound locomotives.....	309
Paper—High speed passenger locomotives.....	317-332
Discussion—High speed passenger locomotives.....	333, 338, 339

T

Thow, William,	
Address.....	34
Thurtell, B. W., Discussion:	
Heating large buildings.....	12, 21
Tests of coal for locomotives.....	149

Timms, James, Discussion:

M. C. B. coupler.....353, 354, 359

Todd, H. C., Discussion:

Tests of locomotive boiler coverings.....189, 209

Tratman, E. E. R., Discussion:

Compound locomotives..... 306

Framing of cars..... 83

Handling cinders from locomotives..... 88

High speed passenger locomotives... 336

V

Vaughn, H. H., Discussion:

Compound locomotives..... 307

W

Waitt, A. M., Discussion:

Adoption of a standard knuckle..... 48

Framing of cars.....79, 85

Heating large railway buildings.....10, 16

Spliced air brake hose.....27, 30, 31

Tests of locomotive boiler coverings.....206, 208

Western Society of Engineers, Invitation from..... 4

Whyte, F. M., Discussion:

Disposal of exhaust from air pump.55, 57, 60

Handling cinders from locomotives..... 93

Handling sand for locomotives..... 98

Hot main pins.....387, 391

Tests of locomotive boiler coverings.....183, 193, 206

Paper—The Framing of Cars.....65-71

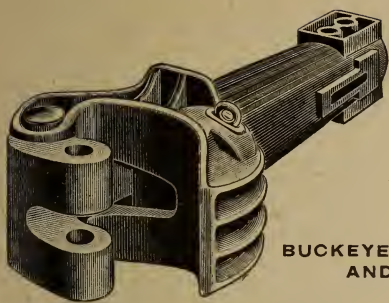
Discussion—Framing of cars.....71, 85

Uses of compressed air about railway shops.....233, 247

Uses of water on hot bearings..... 255

Wickhorst, M. H., Discussion:

Uses of compressed air about railway shops.....240, 246



I

The
"Little Giant
Buckeye
Coupler"

BUCKEYE MALLEABLE IRON
AND COUPLER CO.
COLUMBUS, O.

ESTABLISHED 1825

U. S. I R O N

BROWN & CO., INCORPORATED

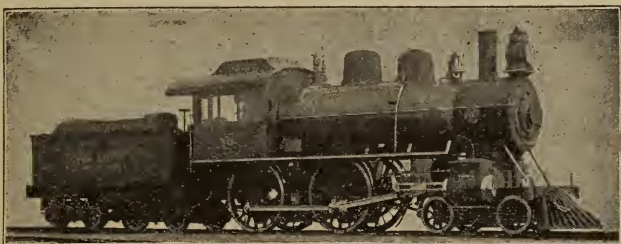
PITTSBURGH, PA.

For Stay Bolts, Piston Rods, and Other Special Purposes

BROOKS LOCOMOTIVE WORKS...DUNKIRK, N. Y.

Builders of Simple
and
Compound
Locomotives..

Annual
Capacity,
400.



THE MURPHY A - B - C SYSTEM OF RAILWAY PAINTING.

.. Send for Pamphlet ..

MURPHY VARNISH COMPANY.

Newark.

Boston.

Cleveland.

St. Louis.

Chicago.

CLASSIFIED INDEX OF ADVERTISEMENTS.

Air Brakes—		Expansion Joints—	
Westinghouse Air Brake Co.....	XIV	Moran Flexible Steam Joint Co....	XIX
Air Brake Pipe and Fittings—		Forgings—Steel and Iron—	
National Tube Works Co.....	V	Cleveland City Forge & Iron Co...	A
Anti-Fiction Metal—		Grain Doors—	
Brady Metal Co.....	A	Chicago Grain Door Co.....	D
Arch Bars—		McGuire Mfg. Co.....	D
Cambria Steel Co.....	XV	Graphite and Graphite Paints—	
Axles—		Detroit Graphite Mfg. Co.....	VII
Cambria Steel Co.....	XV	Jos. Dixon Crucible Co.....	XII and C
B. M. Jones & Co.....	C	Hose—Air Brake and Steam—	
Boiler Tubes—		Boston Belting Co.....	XVI
Allison Mfg. Co.....	XI	Boston Woven Hose and Rubber Co.	III
National Tube Works Co.....	V	Peerless Rubber Mfg. Co.....	IX
Boiler Steel—		Revere Rubber Co.....	XV
Schoenberger Steel Co.....	XI	Injectors—	
Bolsters—Body—		Ohio Injector Co.....	XII
Sterlingworth Ry. Supply Co.....	B	Iron for Piston Rods &c.—	
Brake Beams—		Brown & Co. (Incorporated).....	VI
American Brake Beam Co.....	A	Jacks—	
Chicago Railway Equipment Co.,	B	Chapman Jack Co.....	VI
Sterlingworth Ry. Supply Co.....	B	Joints—Flexible—	
Brake Shoes—		Moran Flexible Steam Joint Co.,...	XIX
Lappin Brake Shoe Co.....	XVII	Journal Bearings—	
American Brake Shoe Co.....	XIII	Brady Metal Co.....	A
Buffer Blocks—		Paul S. Reeves & Son.....	XVII
Gould Coupler Co.....	VII	Sterlingworth Ry. Supply Co.....	B
Bulldozers—		Locomotive Builders—	
Williams, White & Co.....	XI	Baldwin Locomotive Works.....	XX
Car Couplers—		Richmond Loco. & Machine Wks..	IV
Buckeye Malleable Iron & Coup-	I	Schenectady Locomotive Works....	XVII
ler Co.....	I	Brooks Locomotive Works.....	I
Gould Coupler Co.....	VII	Rogers' Locomotive Company....	XII
Latrobe Steel Co.....	D	Locomotive Lagging—	
McConway & Torley Co.....	XX	H. W. Johns Mfg. Co.....	XII
National Malleable Castings Co...	D	Keasbey & Mattison.....	XXII
Pratt & Letchworth Co.....	A	The Franklin Mfg. Co.....	XIX
Standard Car Coupler Co.....	XVIII	Lubricating Oils—	
Trojan Car Coupler Co.....	VII	Galena Oil Works.....	XVI
Car Heating and Lighting—		Machinery for Car & Machine Shops—	
Safety Car Heating & Lighting Co.	IX	Niles Tool Works Co.....	V
Gold Car Heating Co.....	XV	Manning, Maxwell & Moore.....	VI
Consolidated Car Heating and		William Sellers & Co.....	O
Lighting Co.....	XVI	Metal Saws—	
Moran Flexible Steam Joint Co.,	XIX	Q. & C. Co.....	VI
Car Lamps &c.—		Metal Working Tools—	
Adams & Westlake Co.....	X	Niles Tool Works.....	V
Car Roofs and Roofing—		Manning, Maxwell & Moore.....	VI
H. W. Johns Mfg. Co.....	XIII	Mufflers—Steam.	
Car Trimmings—		Ashton Valve Co.....	IV
Adams & Westlake Co.....	X	Oils—	
Car Trucks—		Galena Oil Works.....	XVI
Fox Pressed Steel Equipment Co.	X	Signal Oil Works.....	IX
Drawbar Attachments—		Paints—	
Butler Drawbar Attachment Co.,...	B	Beckwith Chandler Co.....	XVIII
Drilling Machinery—		Murphy Varnish Co.....	I
Prentice Bros. Co.....	XVI	Sherwin-Williams Co.....	IV
Manning, Maxwell & Moore.....	VI	H. W. Johns Mfg. Co.....	XIII
Drills—Twist—		Patterson-Sargent Co.....	D
Cleveland Twist Drill Co.....	A	Phosphor Bronze—	
Engine Lathes—		Brady Metal Co.....	A
Prentice Bros. Co.....	XVI	Pintsch Gas—	
Manning, Maxwell & Moore.....	VIII	Safety Car Heating & Lighting Co.	IX
William Sellers & Co.....	C	Pipe and Pipe Fittings.	
		National Tube Works Co.....	V

INDEX—Continued.

Piston Rods—			Steam Heating Connections—	
B. M. Jones & Co.....	C		Moran Flexible Steam Joint Co.....	XVIII
Pressed Steel Parts—			Steel—Coffin Process—	
Fox Pressed Equipment Steel Co.....	x		Cambria Steel Co.....	xv
Rail Joints—			Steels—Special—	
Continuous Rail Joint Co. of America	C		B. M. Jones & Co.....	C
Reamers—			Schoenberger Steel Co.....	xi
Cleveland Twist Drill Co.....	A		Steel Tired Wheels—	
Rubber Goods—			Steel Tired Wheel Co.....	x
Boston Belting Co.....	XIV		Standard Steel Works.....	XIV
Peerless Rubber Mfg. Co.....	IX		Steel Tires—	
Revere Rubber Co.....	XV		Latrobe Steel Co.....	D
Boston Woven Hose & Rubber Co.....	III		Thos. Prosser & Son.....	VIII
Safety Valves—			Tubes—Boiler—	
Ashton Valve Co.....	IV		Allison Mfg. Co.....	xi
Crosby Steam Gage & Valve Co....	III		National Tube Works Co.....	v
Springs—			Turn Buckles—	
Latrobe Steel Co.....	D		Cleveland City Forge & Iron Co....	A
Stay-Bolt Iron—			Varnishes—	
Brown & Co. (Incorporated).....	I		Chicago Varnish Co.....	VIII
B. M. Jones & Co.....	C		Murphy Varnish Co.....	I
Stay-Bolt Taps—			Beckwith-Chandler Co.....	XVIII
Cleveland Twist Drill Co.....	A		Water Tanks and Cranes—	
Steam Gages—			U. S. Wind Engine & Pump Co....	v
Ashton Valve Co.....	IV		Wheels—	
Crosby Steam Gage & Valve Co....	III		Griffin Wheel Co.....	D
Ashcroft Manufacturing Co.....	VI		Steel Tired Wheel Co.....	x
			Standard Steel Works.....	XIV



CROSBY STEAM GAGE AND VALVE COMPANY.

Standard Locomotive Specialties make a Perfect Equipment.

CROSBY LOCOMOTIVE POP SAFETY VALVES,
Plain or Muffled.

CROSBY STEAM PRESSURE AND DUPLEX GAGES.
CROSBY COUNTER AND PRESSURE RECORDERS.
ORIGINAL SINGLE BELL CHIME WHISTLES.
JOHNSTONE BLOW-OFF VALVES.

CROSBY STEAM ENGINE INDICATOR, with Sargent's
Electrical Attachment for taking any number
of diagrams simultaneously.

MAIN OFFICE AND WORKS, BOSTON, MASS.

Stores, Boston, New York, Chicago and London, Eng.

Send for Catalogue and prices.



VIM

AIR BRAKE HOSE IS THE IDEAL

TWO PLY SEAMLESS FABRIC RUBBER HOSE

BOSTON WOVEN HOSE & RUBBER CO.

Chicago Office...205 Lake St.

THE LONG LIST

of Railway Companies using THE SHERWIN-WILLIAMS PAINTS

is evidence of their superiority.

We make a special paint for every Railway purpose. They are made from the best materials, combined in the best proportions, ground and mixed by the best machinery, operated by the most skillful workmen. They cover most, look best, wear longest, are most economical and always full measure.

THE SHERWIN-WILLIAMS CO.

PAINT AND COLOR MAKERS,

Cleveland, Chicago, New York, Montreal, Boston.

THE SHERWIN-WILLIAMS

Standard Paint

PERFECT METHOD No. 5,

Is exactly suited for use on **METAL SURFACES.**

Protects the metal perfectly, arrests rust, easily applied.

A postal will
bring booklet.



Made by

THE SHERWIN-WILLIAMS CO.

PAINT AND COLOR MAKERS.

Cleveland, Chicago, New York, Montreal, Boston.

RICHMOND LOCOMOTIVE AND MACHINE WORKS

RICHMOND, VA.

Builders of LOCOMOTIVES for every Class of Service

SINGLE EXPANSION AND COMPOUND

ASHTON MUFFLERS POP VALVES AND STEAM GAGES.

MERITS AND REPUTATION
UNEQUALLED.

Our Muffler is the only one with outside top
regulation for the pop. Always available.

THE ASHTON VALVE COMPANY,
BOSTON, MASS.



Water
Cranes



TANKS

U. S. Wind Engine & Pump Co.

BATAVIA, ILL.

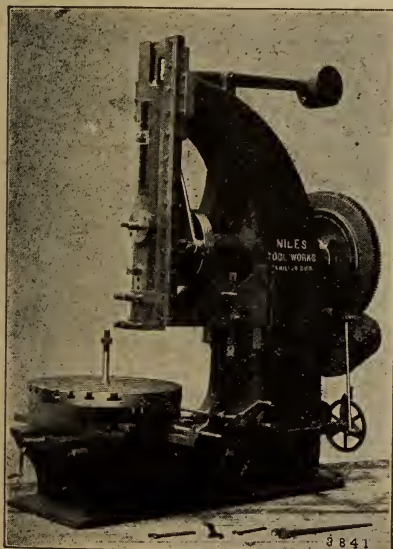
NATIONAL TUBE WORKS COMPANY

CHARCOAL HAMMERED IRON

LOCOMOTIVE BOILER TUBES

THE LARGEST MANUFACTURERS OF SPECIAL MILD STEEL
AND STRICTLY WROUGHT IRON TUBULAR GOODS IN THE
WORLD. FROM ORE TO FINISHED PRODUCT. Sizes $\frac{1}{8}$ to 30 In.

New York Chicago Boston Pittsburgh St. Louis



18-inch Slotting Machine

Machine Tools

Are YOU interested
....in this subject?....

OUR MACHINES ARE BUILT
..for the purpose of..

SAVING LABOR

—and—
THEY ATTAIN THE END FOR
WHICH THEY WERE
DESIGNED.

Correspondence Solicited.
Write for Catalogue.

The Niles Tool Works Co.

Main Office and Works
HAMILTON, OHIO

Branches
New York, Philadelphia, Boston
Pittsburgh, Chicago



CONSOLIDATED SAFETY VALVE CO.

MANUFACTURERS OF

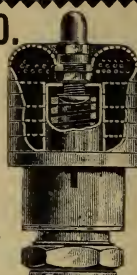
Richardson's Patent Safety Valve and MUFFLERS.

The Muffler is a simple attachment to Richardson's well known
encased Safety Valve. NEAT, COMPACT, DURABLE.
These Valves are the acknowledged standard for the leading
Railroads of the country.

OFFICE & SALESROOM : 111 & 113 LIBERTY ST., NEW YORK.

424 TELEPHONE BUILDING,
PITTSBURGH, PA.

60 SOUTH CANAL ST.
CHICAGO, ILL.



MANNING, MAXWELL & MOORE, RAILWAY & MACHINISTS' TOOLS & SUPPLIES

GENERAL SALES AGENTS FOR

THE POND MACHINE TOOL CO.—Metal Working Machine Tools

THE SHAW ELECTRIC CRANE CO.—Shaw 3-Motor-Electric Traveling Cranes.

THE PEDRICK & AYER CO.—Special Tools for Railroad Repair Shops.

111 & 113 LIBERTY ST., NEW YORK.

424 TELEPHONE BUILDING,
PITTSBURGH, PA.

60 SOUTH CANAL STREET,
CHICAGO, ILL.

THE TROJAN CAR COUPLER CO.

TROY, N. Y.

NEW YORK OFFICE :

36 Wall Street.

CHICAGO OFFICE :

1030 Monadnock Building.

WORKS :
 { Troy, N. Y.
 East St. Louis, Ill.
 Smith's Falls, Ontario, Canada.

M. C. B. TYPE.

The knuckle may be thrown open for coupling by the hand rod at the side of the car, rendering it unnecessary for trainmen to go between the cars to open the knuckle.

Superior Graphite Paint

For Bridges, Roofs, Structural Iron
and all exposed metal or wood surfaces

WARRANTED NOT AFFECTED BY HEAT,
COLD, SALT BRINE, ACID FUMES,
SMOKE OR CHEMICALS.

DETROIT GRAPHITE MFG. CO.

...DETROIT, MICH...

OFFICES:

66 Broadway,
NEW YORK

941 The Rookery,
CHICAGO

319 Commercial Bldg.,
ST. LOUIS

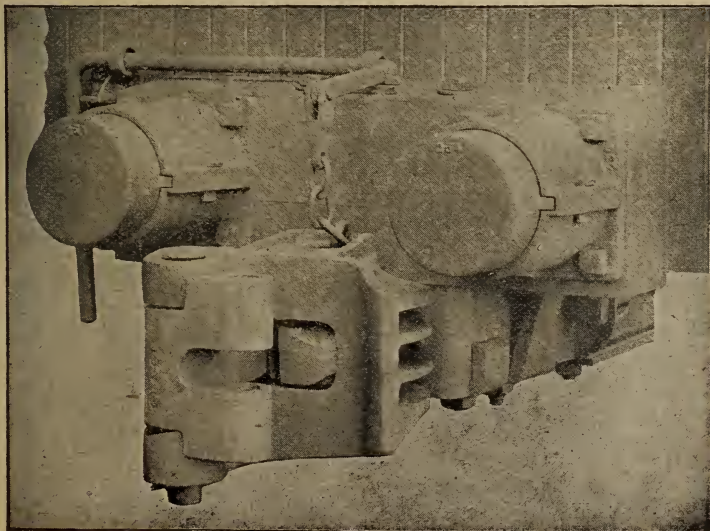
**GOULD
COUPLER
Co.**

WORKS:

Steam Forge,
DEPEW, N. Y.

Malleable Iron,
DEPEW, N. Y.

Cast Steel,
ANDERSON, IND.



GOULD SPRING BUFFER BLOCKS AND
GOULD FREIGHT CAR COUPLER

VIII

THE • CHAPMAN • JACK.

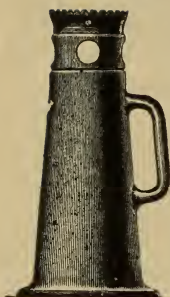
.. PATENTED ..

Always Lubricated and Ready for Use.

.. THE ..

Chapman Jack Co.

CLEVELAND, O.



85,000 MILES OF TRACK

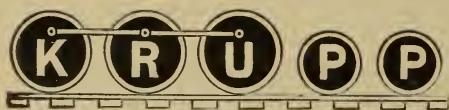
Represent the Railway Constituency of

CHICAGO VARNISH CO.,

Dearborn & Kinzie Streets,
CHICAGO.

215 Pearl Street,
NEW YORK.

Pearl & High Streets,
BOSTON.



STEEL TIRES

ON LOCOMOTIVE DRIVING WHEELS, AND ON STEEL-TIRED WHEELS,
GIVE THE BEST RESULTS FOR EVERY VARIETY OF SERVICE.

THOMAS PROSSER & SON,

15 GOLD STREET, NEW YORK.

OLD COLONY BUILDING, CHICAGO.

LATEST, BEST, CHEAPEST

Q. & C. Automatic Feed Shop Saw

Possesses great advantages over all

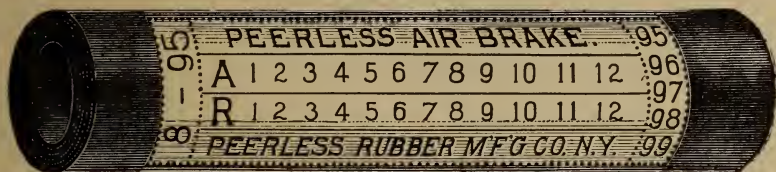
Old style machines.

SEND FOR FULL DESCRIPTION.

Q & C COMPANY, 705 Western Union Bldg., Chicago, Ill.

PEERLESS RUBBER MFG. CO.

Manufacturers of Fine Mechanical Rubber Goods
FOR RAILROAD EQUIPMENT.



16 Warren St., New York.

SAFETY CAR HEATING and LIGHTING ...COMPANY...

PINTSCH GAS—STEAM HEAT.

Used on most of the prominent railways in Europe and the United States

GENERAL OFFICE—160 BROADWAY, NEW YORK CITY,

CHICAGO OFFICE—1017 MONADNOCK BLOCK.

J. C. SIBLEY, President

**Signal Oil
Company,
FRANKLIN, PA.**

..SIBLEY'S PERFECTION VALVE OIL..

The most perfect Cylinder Lubri-
cant known to railway men.

an exclusive use upon nine-tenths of the railway
mileage of this country.

More of Sibley's Perfection Signal Oil is used by rail-
ways than that of all other signal oils combined.

Chicago Branch Office: Western Union Bldg.

Cincinnati Branch Office: Neave Bldg.

X

PRESSED STEEL TRUCK FRAMES

AND PRESSED STEEL PARTS FOR CAR
AND TRUCK CONSTRUCTION.

Fox Pressed Steel Equipment Co.

JAMES B. BRADY, Gen. Sales Agt.

OFFICES:

1416 Empire Bldg., 71 Broadway, New York.

CHICAGO OFFICE:

1407 Fisher Bldg., 281 Dearborn St.

WORKS:

Joliet, Ill. and Pittsburg, Pa.

Eastern Shops and Office
2042 No. Tenth St., Philadelphia

New York Office
26 Cortlandt Street

THE ADAMS & WESTLAKE CO.

Chicago

ELECTROLIERS, CAR LAMPS
LANTERNS, SIGNAL LAMPS, HEADLIGHTS
CAR TRIMMINGS, SWITCH LOCKS
RECLINING CHAIRS, ETC.

THE STEEL TIRED WHEEL COMPANY

MANUFACTURERS OF ALL KINDS OF

Steel Tired Wheels

FOR RAILROAD SERVICE

CORRESPONDENCE
SOLICITED

GENERAL OFFICE

Empire Bldg., 71 Broadway, New York City.

THE ALLISON MANUFACTURING CO.

PHILADELPHIA, PA.

**Tubes for Locomotive, Marine and Stationary Boilers.
Wrought-Iron Pipe for Steam, Gas and Water.**

WESTERN SALES AGENT,

A. M. CASTLE,

6 South Canal St, Chicago.

CHICAGO SALES AGENT,

JOHN S. BREWER,

1030 Monadnock Bldg. Chicago.

FIRE BOX STEEL

PURITY, DUCTILITY AND SOFTNESS

LOCOMOTIVE BOILER,

SMOKE STACK,

TANK AND SHEET

STEELS

MARINE STEEL AND SHIP PLATE

QUALITY UNSURPASSED

PLATES UP TO 118 INCHES IN WIDTH

SHOENBERGER STEEL CO.

PITTSBURGH, PA.

The Ohio Locomotive Injector Economical with Hot Water.

Is always prompt and reliable in starting when feed-pipe is hot or with hot water in the tank, and is highly recommended where feed-water heaters or other heating devices are used.

THE OHIO INJECTOR COMPANY,

Frank W. Furry, *General Manager*,

Works: Wadsworth, Ohio.

1302 Monadnock Block, Chicago.

DIXON'S SILICA-GRAPHITE PAINT

Roofs and iron work properly painted have not required repainting in ten to twenty years. Time only can prove the value of a paint, and Dixon's Silica-Graphite Paint is the **ONLY** graphite paint with a satisfactory time record. For convincing evidence, address

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J.

ROGERS LOCOMOTIVE COMPANY

PATERSON, N. J.

Address **PATERSON, N. J., or 44 Exchange Place, N. Y.**



Builders of LOCOMOTIVE ENGINES
....OF EVERY DESCRIPTION....

R. S. HUGHES, President.
G. E. HANNAH, Treasurer.

G. H. LONGBOTTOM, Secretary.
REUBEN WELLS, Superintendent

ASBESTO-SPONGE FELTED.

ASBESTOS FIRE-FELT.

IN BLOCKS, SHEETS AND SECTIONS.

HIGHEST EFFICIENCY, MOST DURABLE, MOST EASILY APPLIED

STEAM PIPE AND BOILER COVERINGS

Vulcabeston Moulded Rings for Air Brake Pumps. Asbestos Steam Packings. Asbestos Roofing. Roof and Railway Paints

H. W. JOHNS MFG. CO.

NEW YORK
PHILADELPHIA
BOSTON

240 AND 242 RANDOLPH STREET
CHICAGO, ILL.

**LOCOMOTIVE
LAGGING**

THE DIAMOND "S" BRAKE SHOE

===== Friction =====

===== Strength =====

===== Durability =====

===== Uniformity =====



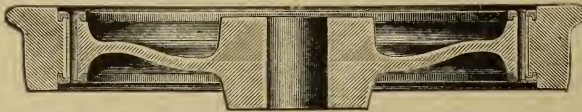
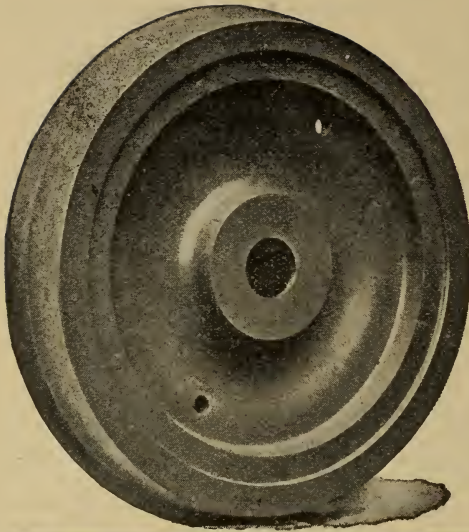
===== **ECONOMY** =====

THE AMERICAN BRAKE SHOE CO.

THE SARGENT CO.
CHICAGO, ILL.

RAMAPO IRON WORKS
HILLBURN, N. Y.

PARKER & TOPPING
ST. PAUL, MINN.



SECTION OF PLATE WHEEL.

THE
Standard Steel
...WORKS...

1103 HARRISON BUILDING
PHILADELPHIA

STEEL TIRES

....for....

Locomotive Driving Wheels

Steel Tired Wheels

with

WROUGHT IRON CENTERS
Plate or Spoke

Western Offices

1217 Monadnock Block
CHICAGO, ILL.

C. A. THOMPSON
ST. LOUIS

THE WESTINGHOUSE AIR BRAKE CO.

PITTSBURG, PA., U. S. A.

—MANUFACTURERS OF THE—

**WESTINGHOUSE
AUTOMATIC**

BRAKE

Now in use on 33,500 Locomotives and 650,000 Cars.

THE AMERICAN BRAKE COMPANY,

The Westinghouse Air Brake Co., Lessee.

NEW YORK OFFICE, 1207 HAVERMEYER BLDG.

CHICAGO OFFICE, ROOKERY BUILDING,

MANUFACTURERS OF

LOCOMOTIVE BRAKES,

General Offices, St. Louis, Mo.

Revere Rubber Co.

HOSE

Boston

New York

Chicago

GOLD CAR HEATING CO.

NEW YORK AND CHICAGO.

Nearly 10,000 Cars and Locomotives equipped with our Systems of Steam Heat.

The Gold Straight Port Coupler is the only one extant having an
Adjustable Brass-Faced Seat.

CATALOGUES AND CIRCULARS WILLINGLY FURNISHED ON

668 THE ROOKERY, APPLICATION.

CHICAGO, ILL.

NO. 6 BRIDGE STORES,

NEW YORK.

Cambria Steel

**Car Axles.
Locomotive Axles.
Crank Pins. Piston Rods.**
Toughened by Coffin's Patented Process.

CAR AND LOCOMOTIVE STEELS.

ADDRESS

CAMBRIA STEEL CO., Philadelphia, Pa.

ST. LOUIS OFFICE,
716 N. Second St.

CHICAGO OFFICE,
209 Western Union Bldg.

NEW YORK OFFICE,
71 Broadway

GALENA OIL COMPANY, Franklin, Pa.

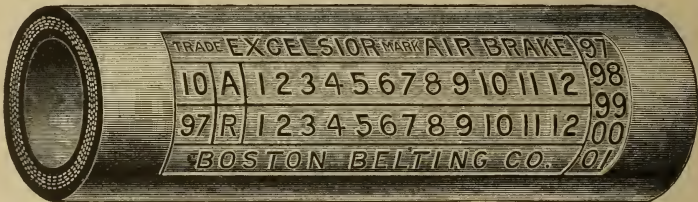
CHAS. MILLER, President.

GALENA OILS are the standard railway lubricants of America.
GALENA OILS are used exclusively on nineteen-twentieths of the total railway mileage of the United States, Canada and Mexico.
GALENA OILS lubricate the fastest trains in the world and hot bearings as a result of defective lubrication are unknown to the patrons of Galena Oil Company.

Galena Oils are Manufactured Exclusively by Galena Oil Company.

Principal Office and Works, FRANKLIN, PA.

THE STANDARD OF EXCELLENCE.



BOSTON BELTING CO.,

Manufacturers of

256 Devonshire Street, BOSTON, SUPERIOR RUBBER GOODS For Railroad Equipment.

DRILLING MACHINERY AND ENGINE LATHES

For Locomotive, Car and Bridge Builders, Boiler Shops,
Ship Yards, Etc.

PRENTICE BRO'S. COMPANY

CATALOGUE FREE.

WORCESTER, MASS.

Consolidated Car Heating and Lighting Company

ALBANY, N. Y.

....Direct Steam and Hot Water Heating Systems for Railway Cars....

JAMES F. McELROY, Consulting Engineer

WESTERN AGENCY, 514 WESTERN UNION BUILDING

SEND FOR CATALOGUE

CHICAGO, ILL.

SCHENECTADY LOCOMOTIVE WORKS

SCHENECTADY

...N. Y...

ESTABLISHED 1848



COMPOUND LOCOMOTIVES

Showing Economy of 15 to 25 per cent in Fuel and Water..Annual Capacity 450

WM. D. ELLIS,	A. J. PITKIN,	A. P. STRONG,	A. M. WHITE,	J. E. SAGUE,
Pres. & Treas.	V-Pres. & G. Man.	Sec'y	Supt.	Mec. Engineer

PAULS. REEVES & SON, Philadelphia, Pa.
Phosphor Bronze and BABBITT METALS.

BRASS AND PHOSPHOR BRONZE CASTINGS

❖ for Locomotives and Cars a specialty. ❖

LAPPIN BRAKE SHOES

FOR LOCOMOTIVES AND CARS.

A solid casting having alternate soft and chilled sections. Will outwear from four to six common shoes. Shows highest per cent. of braking power without skidding wheels or cutting tires. Sets for testing furnished without charge.

LAPPIN BRAKE SHOE CO.

Western Agent, F. P. Collier, 658 Rookery, Chicago. General Office, 39 and 41 Cortlandt St., New York. Works, Bloomfield, Essex Co., New Jersey.

XVIII

BECKWITH-
CHANDLER & CO.
HIGH GRADE
VARNISHES.
621
BROADWAY
New York.

AS A NERVE TONIC IS TO MAN, SO IS

The Standard Steel Platform

TO THE CAR—

...IT GIVES STRENGTH AND PREVENTS COLLAPSE...

STANDARD COUPLER CO.

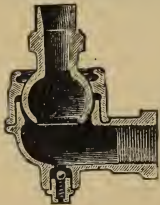
26 Cortlandt Street, New York

The Moran Flexible Steam-Heating Connection

(ALL METAL)

ESPECIALLY APPLICABLE

BETWEEN ENGINE AND TENDER.



Moran Flexible Steam Joint Co., Inc'd,

NO. 149 THIRD ST., LOUISVILLE, KY.



XIX

CHAS. J. S. MILLER, Pres. FRANK H. JOHNSON, Sec. and Treas.
R. J. EVANS, Gen. Manager.

THE FRANKLIN MFG. CO.

FRANKLIN, PENN.

Monarch Asbestos-Magnesian Sectional Boiler Laggings

The Method of Application and Fastening Enables Removal, When Necessary, of Single Blocks or the Entire Covering, Without Injury to Same.

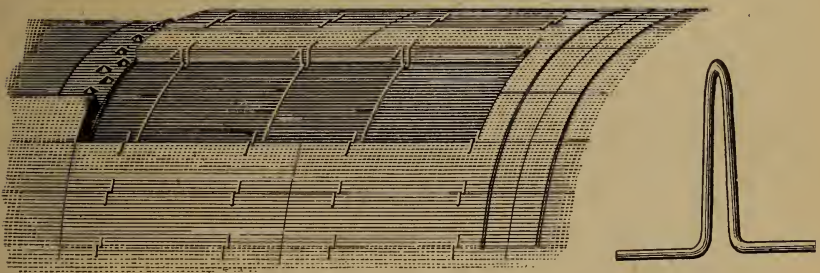


ILLUSTRATION OF FASTENING

Send Blue Prints

Estimates of Cost will be made from blue prints, drawings or sketches, and these are also necessary in giving orders, to insure Accuracy. State the Thickness of Covering Desired. Have in Mind that A Good Covering will Save its Cost Many Times Yearly.

Asbestos Cement Felting

This is another grade of our Laggings, very popular with customers desiring a plastic covering at low cost, thoroughly effective. This is a dry cement for locomotive boilers, domes, etc., composed of Asbestos Fibre and Cementing Compounds; an excellent non-conductor, easily applied, is a preservative of iron, and will not shrink, crack or jar off. It is put up for shipment in bags of 140 pounds each, which is a sufficient quantity to cover about 40 square feet, 1 inch thick. To apply, mix with water to the consistency of mortar, put on a light coat first and then cover to the desired thickness. In case of a boiler, have the surface to be covered warm, if practicable to do so. This Cement Felting is used on steam chests and to fill the exposed cavities of cylinders.

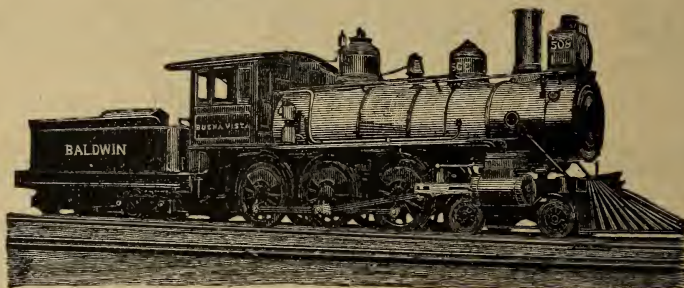
ASBESTOS PIPE COVERINGS, MILL BOARD, PACKINGS, PAPERS, ETC.
Also Sole Manufacturers of the Celebrated Perfection Journal Box Packing.

Represented by **GEO. W. CUSHING, M. E., 308 Western Union Bldg.**
CHICAGO, ILL.

XX

BALDWIN LOCOMOTIVE WORKS.

ANNUAL CAPACITY 1,000.



LOCOMOTIVE ENGINES

Adapted to every variety of service, and built accurately to standard guage and templates. Like parts of different engines of the same class perfectly interchangeable.

COMPOUND LOCOMOTIVES. Broad and Narrow Gauge Locomotives; Mine Locomotives by steam or compressed air; Plantation Locomotives, Noiseless Motors for Street Rys., etc.

BURNHAM, WILLIAMS & CO., Proprietors, Philadelphia, Pa.

THE JANNEY CAR COUPLER

—FOR—

Freight Passenger Cars,

—MADE ONLY BY—

THE McCONWAY & TORLEY CO.

PITTSBURGH, PA.

CHICAGO OFFICE, Great Northern Building.

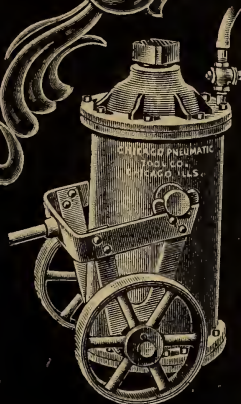
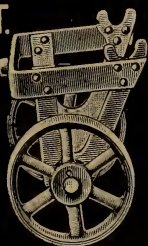
Chicago Pneumatic Tool Co.

635 MONADNOCK BLOCK,
CHICAGO.

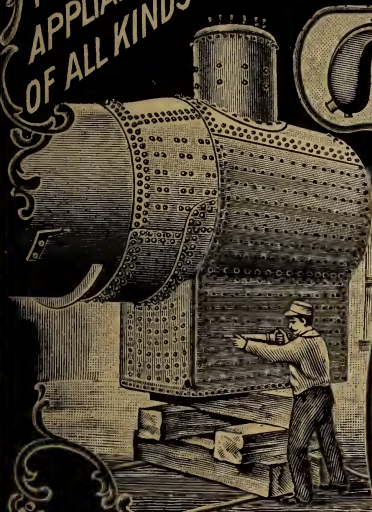
1006 BEARD BLDG.
122 LIBERTY ST.

NEW YORK.

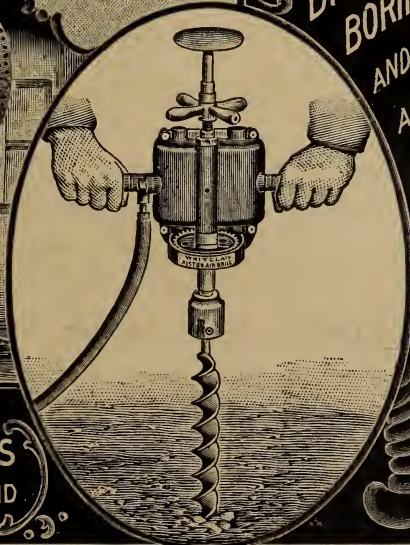
THE LATEST
AND BEST
PNEUMATIC
APPLIANCES
OF ALL KINDS



PNEUMATIC CAR JACKS OF ANY CAPACITY



PISTON AIR
DRILLS FOR
BORING WOOD
AND DRILLING
IN IRON



"THE BOYER"
PNEUMATIC HAMMERS
FOR CHIPPING CALKING AND
RIVETING.

XXII

KEASBEY & MATTISON

COMPANY'S

Sectional MAGNESIA LAGGING

**IS THE BEST
BECAUSE IT IS ALWAYS FIRST**

FIRST

AS A NON-HEAT CONDUCTOR

FIRST

IN ITS STRUCTURAL STRENGTH

ALLOWING IT TO BE REMOVED AND REAPPLIED WITHOUT BREAKAGE

FIRST

IN INDESTRUCTIBILITY

**Magnesia Lagging will outlast any boiler, or any dozen boilers. Can
be removed from old boilers and applied to new ones.**

With care it lasts forever.

SEND YOUR BLUE PRINTS TO THE

**KEASBEY & MATTISON
COMPANY**

AMBLER,

PENNA.

(A)

CLEVELAND TWIST DRILL CO.



21 YEARS
EXPERIENCE

STAYBOLT TAPS, REAMERS, TWIST DRILLS

CORRESPONDENCE SOLICITED

CLEVELAND, OHIO

OFFICIAL
PROCEEDINGS

VOL. 11—No. 9.

MAY 25,
1899

Western Railway Club

Organized
April, 1884.

Incorporated
March, 1897.

PAPERS PRESENTED AND DISCUSSED:

Notes on Hot Main Pins

Mr. C. H. QUEREAU.

ANNUAL REPORTS OF OFFICERS.

ELECTION OF OFFICERS FOR 1899-1900.

...Next Meeting, September 19, 1899...

MAGNUS METAL

Record, 425 Miles in 426 Minutes. The best and purest composition engine metal made. In use on more than 4,500 Railway Engines for Driving Boxes, Rod, End, Tender and Truck Brasses. Forty-one High Speed Passenger Trains running from all points, Atlantic to Pacific, are using our Metals.

BRADY METAL CO., } 100 BROADWAY,
NEW YORK.

Engine Castings and Car Bearings (all patterns), Babbit Metal, Etc.

TURNBUCKLES



CLEVELAND CITY FORGE AND IRON CO., CLEVELAND OHIO

POOLEY COUPLERS
Pratt & Letchworth Co.
BUFFALO, N. Y.

**MALLEABLE &
STEEL CASTINGS**

Kewanee Brake Beam
Universal Brake Beam

Schoen Steel Beam
Central Steel Beam

MADE BY

AMERICAN BRAKE BEAM CO.,
1023 Monadnock Bldg., Chicago.

(B)

The Butler Drawbar Attachment Co.

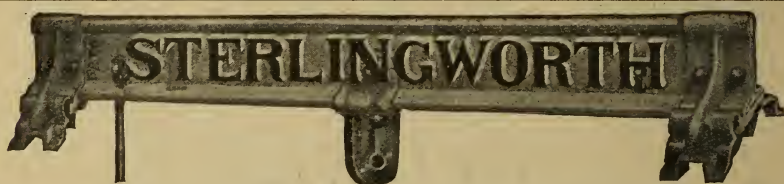
CLEVELAND, O.

200,000 SETS NOW IN USE

ON LEADING RAILROADS OF THE COUNTRY.

Endorsed by Railway Mechanical Departments
as the BEST YOKE DEVICE on the Market.

AN ABSOLUTE SPRING PROTECTOR.



ROLLED STEEL BRAKE BEAMS

FOR ALL CLASSES OF EQUIPMENT

No Failures—300,000 in Service on Over 140 Roads—Standard on Many

Specify "STERLINGWORTH" and get the Best

HOME LIFE BUILDING
256 Broadway, New York

General Offices and Works
EASTON, PA.

W. W. BUTLER, Western Mgr.
Great Northern Bldg., Chicago

H. S. BURKHARDT, President.

E. B. LEIGH, Vice-Pres. and Gen. Mgr.

Chicago Railway Equipment Co.

LESSEE.



STANDARD ON MAJORITY OF TRUNK LINES AND LEADING ROADS
NEARLY 1,500,000 NOW IN USE

AUTOMATIC FRICTIONLESS SIDE BEARINGS

Saves Wheels and Rails.

Reduces Cost of
Transportation.

Prevents Derailments, &c.

Improves the Riding of Cars.



Merit Proven in Service.

In Use on 70 Railroads.
Prices and Full Information on Application.
Send for Catalogue.

GENERAL OFFICE AND WORKS:

40TH AND PRINCETON AVENUE, (HOPKINS ST.) CHICAGO, ILL.

City office, Suite 701-2 Great Northern Bld. N. Y. Office, Room 21, 2d Floor, 100 Broadway

Canadian Factory, F. E. CAME, Agt., Montreal, Que.

Southern Agent, B. F. PILSON, Richmond, Va.

(C)

TAYLOR ^{BEST} YORKSHIRE STAYBOLT IRON

USED BY LEADING RAILROADS.

R. MUSHET'S ^{SPECIAL AND TITANIC} STEELS

Sole Representatives in the United States:

B. M. JONES & Co.

BOSTON, 81 Milk Street.

NEW YORK, 143 Liberty Street

Dixon's Pure Flake Graphite

Has during 1896 saved thousands of dollars to railroad companies. It has cured hot pins and hot journals when everything else has failed. It saves oil and coal and time. It is endorsed by engineers, master mechanics, superintendents of motive power and all railway officials.

JOSEPH DIXON CRUCIBLE CO.

May We Send You Our Pamphlet?

Jersey City, N. J.

William Sellers & Co. Incorp.

PHILADELPHIA,
PA.

Labor Saving Machine Tools, Etc.

High Speed Traveling Cranes. Swing Cranes.

New and Improved Designs of

Axle Lathes for Car and Driving-Wheel Axles.

Boring and Turning Mills. Car Wheel Boring Mills.

Tool and Drill Grinding Machines

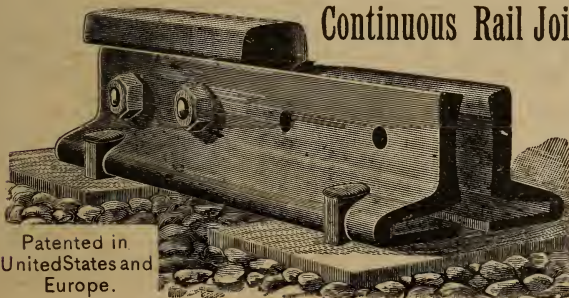
Turntables.

Shafting.

Injectors.

Continuous Rail Joint Co. of America

913 Prudential Bldg.
Newark, N. J.



Patented in
United States and
Europe.

Fewest Parts.
Strongest and Safest,
Best Economical Results.
Provides for increased
Tonnage up to date.

Millions in use on 78
Railroads.

Occupies no Room.
No Expense for Repairs.
Guaranteed for 5 Years.

CHICAGO GRAIN DOOR

Use the Best Door Made.
Monadnock Block,
CHICAGO.

GRIFFIN WHEEL COMPANY **CAR AND ENGINE WHEELS**

CHICAGO

ST. PAUL

DETROIT

TACOMA

DENVER



The B. P. S. Paints for Freight Cars
are Superior to all others.

The B. P. S. "Nobrac" Paint
is the best preservative for Iron and Steel
parts in Car Construction, Bridges, etc.
It Prevents Corrosion.

THE PATTERSON-SARGENT CO
CLEVELAND, OHIO.

LATROBE STEEL COMPANY

MANUFACTURERS OF
LOCOMOTIVE AND CAR WHEEL

TIRES

...AND...

WELDLESS STEEL FLANGES

FOR
HIGH PRESSURE STEAM, WATER AND GAS LINES.

MAIN OFFICE

1200 GIRARD BUILDING
PHILADELPHIA

...WORKS...

LATROBE, PENNA.

BRANCH OFFICE

71 BROADWAY
NEW YORK

THE TOWER COUPLER

..... FREIGHT, PASSENGER AND LOCOMOTIVE

Malleable Iron
Castings
FOR
Railroad Use

THE NATIONAL MALLEABLE CASTINGS CO.

CLEVELAND CHICAGO INDIANAPOLIS TOLEDO

Star Grain Door.
500,000 IN USE.

MCCUIRE MFG. CO.

- RECEIVED -
THE ONLY
World's Fair Medal

UNIVERSITY OF ILLINOIS-URBANA



3 0112 110986186